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OUR COVER

This month's cover illustrates the five-valve receiver described in this issue. It is unusual in possessing a stage of R.F. amplification, and is quite out of the ordinary run of "fives."

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COLOUR TELEVISION IN BRITAIN

A recent report from London stated that the Director-General of the British Broadcasting Corporation, Sir Ian Jacob, has expressed the hope that colour television will be broadcast in the United Kingdom within ten years. While the connection may not at first be apparent, we believe that this somewhat guarded statement has in it extremely important implications which are not without their application to a problem which is exercising us, in New Zealand, not a little. We refer, of course, to the still undecided Government policy with regard to the setting up of a television broadcasting system in this country.

One of the major decisions that the Government must make is that of the standards to be used, and this is an exceedingly difficult one to resolve. One school of thought states that we would be unwise to settle on the B.B.C. 405-line standard, since at some unspecified future date, Britain itself may change from this standard on to one with more lines per picture. It is unlikely, these people say, that the 405-line standard can last indefinitely, in view of the fact that other countries setting up TV systems are almost all choosing the C.C.I.R. 625-line standard, with its (theoretically at least) much higher standard of definition. They also point out that since a logical development in television broadcasting is the introduction of colour, Britain will probably be forced off the 405-line standard as soon as she decides to engage in colour TV.

There are, however, other arguments. In the first place, many competent observers have given as their opinion that the British 405-line system gives as good or better pictures *in the viewers' homes* than either the American 525, the C.C.I.R. 625, or even the French 819-line systems. The B.B.C. was right, they say, in its decision to stick to the pre-war 405-line system, because it gives just as acceptable performance with lower receiver cost.

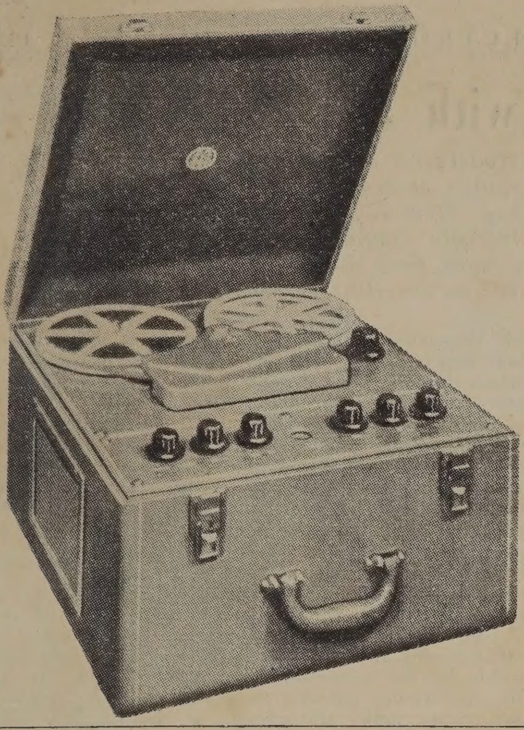
Now comes the announcement by the Director-General of the B.B.C. that colour will probably be introduced into the British system within ten years. But that is not all. Sir Ian Jacob also said that any system of colour that might be introduced must be compatible. That is, it must not render obsolete existing receivers, in that these must be able to receive the colour broadcasts in monochrome. The operative word here is *existing*. It looks very much as though the B.B.C. research department, which is known to have been experimenting with colour for some time, may have developed a colour system which is compatible with the 405-line system, and which will enable colour reception to be obtained with no loss of definition and general picture quality using this system. Now this is certainly a tall order in the way of technical development, but it is by no means impossible. Until very recently, it may have been considered so by even the most competent and learned engineers, but behind-the-scenes development has been so rapid lately that now the possibility of such a system being developed can by no means be excluded. While it is true that Sir Ian did not say how soon he considered colour broadcasts could start, his mentioning the topic at all in a review of the B.B.C.'s plan for TV development is significant. Its introduction was still dependent on technical progress, he said, but it is not difficult to guess that the B.B.C. research department must have already travelled a long way on the road to the successful development of a compatible 405-line colour system of commercial quality, for him to be willing to discuss the project even with such definiteness as he has done.

In passing, Sir Ian's plans for the future of TV as a whole are of considerable interest. Five new medium-powered stations are to be built, and these, together with the present five high-powered ones, will give TV coverage to 90 per cent. of the population of the British Isles. The next step will be to re-build the existing London station, which uses the same transmitter as was originally brought into service in 1937, when it was the first station in the world to be giving a regular high-definition service to the public. Finally, eight low-powered stations will fill in the gaps to increase the coverage to 95 per cent. of the total population.

Present hours of TV broadcasting are five hours daily, and it is proposed to extend these to seven, and to introduce a "news service in vision."

These extensions to the present by no means inconsiderable system will obviously cost a great deal, but Sir Ian hoped that they would not mean more than an increase in the combined sound and television licence from £2, as now, to £3 some time within the next ten years.

It is particularly pleasing to see that Britain, if the B.B.C. has its way, will retain the world leadership in television that it obtained when it commenced regular broadcasts in 1937. Moreover, it will be a great pity if this country cannot keep up with international progress by instituting its own television service long before the B.B.C.'s renewed ten-year charter expires.



A Five-Valve Receiver with an R.F. Stage

There seems to be a steady demand among readers for small broadcast receivers of from three to five valves, and of recent months, several sets of this kind have been quite popular, to judge from our mail-bag. Here is something quite new in the way of five-valve receivers, which is specially designed to work on short aerials, and has excellent sensitivity. Unlike most fives, it has a stage of R.F. amplification, which largely accounts for its excellent performance.

INTRODUCTION

The chief use to which modern multiple valves are put is to reduce to a minimum the number of valves which have to be used to produce a receiver of acceptable performance. We take very much for granted valves like the double-diode triode, which enable the one "bottle" to perform three distinct and separate functions, but even with the low price of modern valves, these multiple tubes are really the only means by which a satisfactory set can be built without using an uneconomic number of tubes. Consider for a moment how the cost of what we now call a conventional five-valve set would be increased if every function in the set had to be performed by a separate valve, as was the case in the early days of radio. We would have one valve for the mixer, another for the oscillator, one as I.F. amplifier, one each as detector and A.V.C. rectifier, one as audio amplifier, another as output stage, and another for the power rectifier. This makes eight valves, and even then we have only counted the rectifier as one valve, when it should rightly be considered as two! A count of the number of separate tubes needed for, say, an eight-valve set with a push-pull output stage and a few other frills is even more instructive, and shows just how dependent we are today on the multiple valve!

The comparative recent advent of extremely sensitive output pentodes which include in the same envelope a pair of diodes has made possible sets of only four valves with almost identical performance to that of the conventional five, the only difference being the slightly smaller audio amplification of the smaller set. Another approach to the problem of making a good receiver in the smallest possible number of valves is to do what we have in the set to be described in this article. This is to use five valves, but to replace the conventional audio voltage amplifier stage by a stage of R.F. amplification. The audio end of the receiver is similar to that of the present-day commercial four-valve set, consisting of a high-sensitivity pentode fed directly from the diode detector, thus making room for the extra valve without exceeding a total of five.

VALVE LINE-UP

One of the qualities of this circuit that will recommend it to many builders is its high sensitivity, and this is not obtained solely on account of the R.F. stage. Important, too, in this direction are the valves used, and the coils and I.F. transformers. The valves have been chosen from the modern British and Continental loctal series, of which the oscillator-mixer tube, the ECH21, has as high a conversion gain as any valve available, if not slightly higher. The EF22, also, has a high mutual conductance for a conventional R.F. pentode designed for use in broadcast and short-wave receivers.

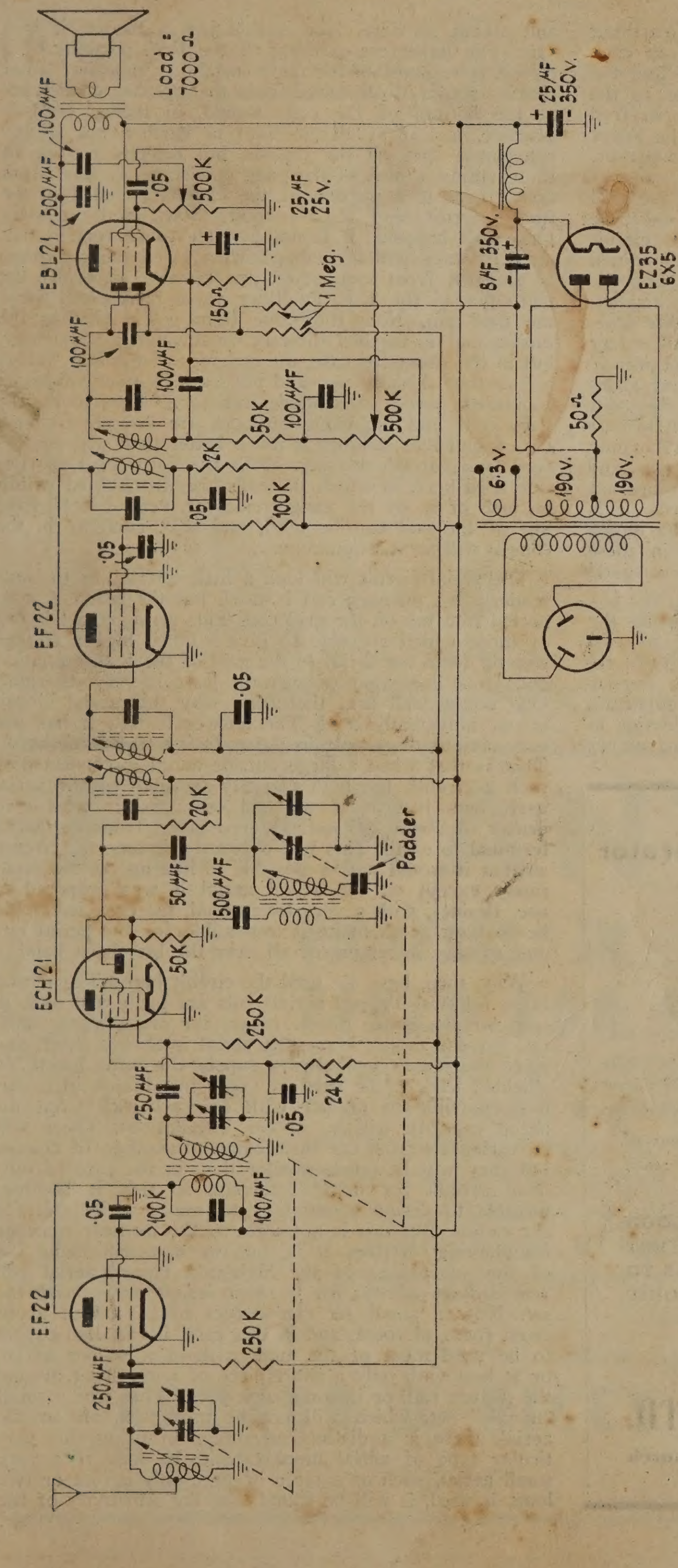
The coils, too, are the newest designs to be turned out by a well-known New Zealand maker, and in spite of their compactness, give a better account of themselves than many older designs which are much larger physically. On account of their small size, these coils lend themselves admirably to compact construction, where this is needed. They have been used in the present instance, to build up a small tuning unit comprising a midget three-gang variable condenser, with a built-on dial movement, and the aerial, R.F., and oscillator coils. Two diagrams printed herewith show how the metal-work for this unit, in the form of a rather unconventional-looking box, can be made from light-gauge aluminium sheet. The gang condenser is screwed to the top of this box, and the flange in front supports the dial assembly, which is rigidly affixed to the gang. It also forms a firm support for the whole assembly. The three coils are mounted on the right-hand side of the box, as seen in the drawing, in a straight line, with each coil opposite its own gang section. The connections from the coils are made inside the box, this being made possible by the removable side, which is put on only after the wiring between the gang, the coils, and the main circuit under the chassis of the set, have been completed.

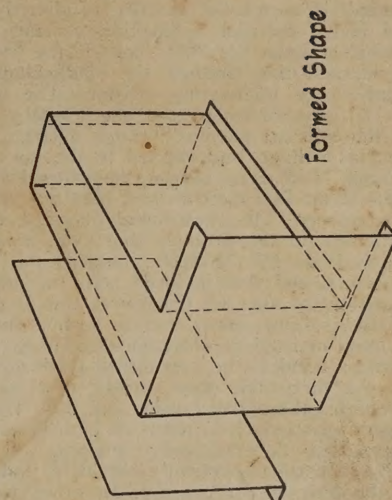
SOME CIRCUIT POINTERS

Those readers who have followed fairly assiduously the various circuits we have published over a period of years will find in this one a number of differences from earlier ones. These circuit differences are those that one might expect to find between the circuit arrangements of different manufacturers. They have relatively little effect on the main attributes of a receiver, but each has its own small advantage. Some of them, it may be said, have no noticeable effect on performance, and yet are desirable because they enable a reduction to be made in the number of small parts used, and in the amount of wiring to be done in constructing the set. A major item of this sort is the arrangement which has been used for obtaining bias for the R.F., oscillator-mixer, and I.F. stages, together with the somewhat unusual way of feeding the A.V.C. voltage to the grids of these valves. Together, these circuit dodges result in the saving of these resistors and five condensers, and so can be reckoned well worthwhile on this score alone.

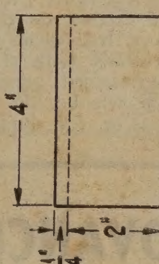
As a brief examination of the circuit diagram will show, bias for the R.F. and I.F. sections of the set has been obtained by inserting a small back-bias resistor of only 50 ohms in the lead from the centre-tap of the power transformer to earth. Then, via the A.V.C. circuit, the grids of the first three tubes are returned to the "hot" end of this resistor, which is at a potential of approximately —2 volts with respect to the chassis. The whole H.T. current of the set passes through the 50-ohm resistor, and since the greater portion of this is that drawn by the output valve, the voltage across the resistor, and therefore the standing bias on the R.F. tubes, is approximately constant.

The other feature is the use of a parallel-feed arrangement in the grid circuits of the first three valves. This point has no real connection with the first one, because the more ordinary series-feed connection could have been used equally well. By parallel, or shunt feed, as it is

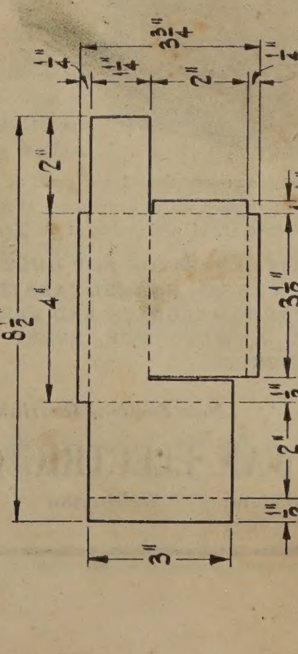




Showing final shape of sub-chassis.



Lid of sub-chassis



Working drawing of sub-chassis.

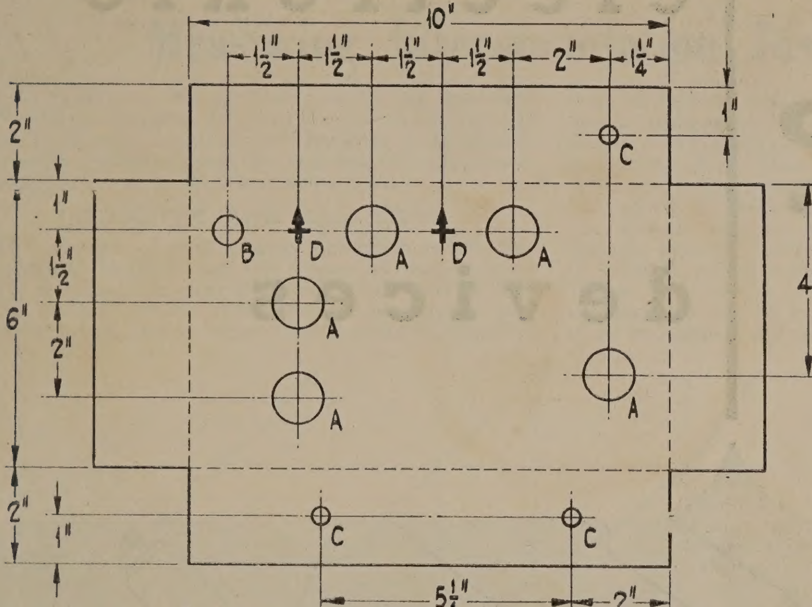
also termed, is meant the practice of directly earthing the grid coils, inserting a blocking condenser in each grid circuit between the "hot" end of the coil and the valve grid, and then feeding the bias voltages to the grid through a high-value resistor. The series-feed method is the more often used one whereby the lower ends of the coils are earthed through a large condenser, and the bias voltage is connected to the lower ends of the coils, no blocking condensers being used at the grid ends. The shunt-feed method used here was at one time hardly ever seen. This was mainly because the circuit was criticized on the grounds that even a high-valued resistor, such as 250 or 500k., reduced the Q of the tuned circuits, and thus reduced both the amplification and selectivity of the set. Of course this is quite true, both of these things occur, but to such a small extent that no one could tell the difference except by the use of instruments; besides, the arguments used several years ago do not carry the same weight now as they did then, because, these days, coils and I.F. transformers have improved so much in terms of high Q and dynamic resistance, that the maximum amounts of gain and selectivity that are theoretically obtainable today are not necessarily desirable in practice. In other words, it is now possible to have too much stage gain and too much selectivity, so that the very slight reduction in these quantities caused by shunt feeding the valves is a "good thing" rather than the reverse.

There is, however, a very good reason for using the shunt-fed circuit, quite apart from the saving of two condensers. It is easier to obtain complete stability of the signal circuits with shunt-feed than with the conventional series-feed arrangement. This is an important advantage, whether the set is designed for production in a factory, or for duplication by amateur constructors

and others, as here. Nor is this just a theory, it is a fact. The imperfect earthing of the R.F. portions of a circuit is responsible for more instability than any other single factor. With series-feed, the by-pass condensers at the bottom of the coils should, in theory (and in practice, too, if at all possible) be earthed not at any convenient spot on the chassis, but directly to one of the earthing wipers of the gang condenser. If this is not done, there is a portion of the chassis included in the tuned circuit, and R.F. currents flow in the chassis. Once this happens, it is not possible to be certain that an R.F. stage will be stable however well the coils may be shielded from each other, and however carefully the plate pin of the R.F. amplifier valve is shielded from the grid pin. Now the same thing goes whether the tuning coil is earthed directly or through a condenser, but in the shunt-fed case, the cathodes of the R.F. valves are earthed directly too, and not by a by-pass condenser connected across a cathode resistor. When both the R.F. coils and the valve cathodes are directly earthed, it is found that stability is much better than with series-feed, and cathode biasing. With the form of construction used here, in which the coils are all mounted within an inch or so of the gang condenser, very direct earthing of the coil can be used, and R.F. currents in the chassis will be at a minimum.

The aerial circuit will look a little unfamiliar to some readers. No primary coil is used, but the aerial is connected to a tap on the grid coil. This arrangement is one of those which are able to give a much higher voltage step-up from the aerial to the grid of the R.F. amplifier, and from one point of view at least is very desirable. One might well ask, therefore, why this aerial circuit is not universally used. The answer is that it has one very serious drawback, in the ordinary course of events. That is that when a large outside aerial is connected to such a circuit, the high capacity to earth of the aerial itself acts just as if we had connected a fixed condenser of about 200 $\mu\mu$f. or even more, from the aerial terminal to earth. This will obviously de-tune the circuit, so that it would not be possible to line up the set accurately except on the actual aerial it was proposed to use. Besides, with a very long aerial, the capacity would be so high as to make it impossible for the aerial circuit to stay in alignment all over the broadcast band.

Why, then, have we used the circuit here? The reason is as follows. Tapped aerial coils are made and sold, in spite of the above disadvantage, for one purpose only, i.e., for car radios. Here, the aerial is always short, and since the maker can always supply the same length of shielded lead, to be used in every installation in a car, it is possible to predict with fair accuracy what the aerial capacity will be in car installations. There will be variations from one installation to another, of course, but they will be much smaller than in the case of outdoor aerials for home receivers, so that it becomes possible to design a satisfactory tapped aerial coil for car radios. But this is not a car radio, we hear someone complaining. Neither it is, but we can still make use of the advantages of the high-gain tapped aerial coil *provided we always use a short indoor aerial with the set.* Now a small set can expect to be moved about from room to room, and in this case, it can also expect to be used most of the time without a proper aerial, or at best with only a short piece of wire, slung around the picture rail, or in some such place. Thus, for a small "mobile" set, which will not be used with an outside aerial, there is a distinct advantage in using this particular type of aerial input circuit. In fact, if a very small aerial, such as a piece of wire only a foot or two long, is used, it will be found that the sensitivity of the



Drillings:
A = $1\frac{1}{8}$" Dia. B = $\frac{5}{8}$" Dia. C = $\frac{3}{8}$" Dia.
D = To Suit I.F. Transformer

set is very much greater if a tapped aerial coil is used. Not that such a short aerial is to be recommended, because the original model was aligned with about ten feet of wire attached to the aerial lead. On this, the performance was amazingly good, the dial being covered with readable and listenable signals in the evenings, and giving excellent reception of the more distant YA and ZB stations during the day.

Of course, if you want to use an outdoor aerial on the set, there are two courses open. One is to put a condenser of about 50 to 100$\mu\mu$f in series with the aerial lead, right at the set, and the other is to install a conventional aerial coil. The manufacturer makes both in this new range, and one can choose whichever aerial coil he pleases.

The oscillator in this set uses a circuit that is not often seen. It is referred to as a plate-tuned oscillator circuit, and reference to the diagram shows that the tick-

(Continued on Page 48.)

AUDIOFACTS No.4

Measuring Intermodulation Distortion

Last month, in No. 3 of this series, we described how intermodulation came to be recognized as the most unpleasant result of non-linearity distortion in amplifiers, speakers, pick-ups, and indeed in any component part of an audio reproducing chain.

LINEARITY AND ALL THAT

The mention of non-linearity distortion in the last paragraph reminded us that some of our readers might not be quite clear as to what is meant by this term. In last month's Audiofacts, it was stated that both harmonic and intermodulation distortion arise in any device whose curve of input versus output is not a straight line, and this rather blunt statement needs a little elucidation. Let us suppose that the device in question is an amplifier, and that we want to see whether it is free from distortion or not. The obvious way to do this is to use a sine-wave oscillator and a wave analyser. The former provides a distortionless signal, containing no harmonics, and we feed this into the input terminal of the amplifier. The wave analyser is simply a complicated sort of vacuum-tube voltmeter which will tell us the strength of any harmonics which may be present in the output of the amplifier, so that by measuring the amplitude of all the harmonics that the analyser can find, we can estimate the degree of harmonic distortion that is present. However, this equipment is not likely to be found in any but the most lavishly equipped laboratories, so we must think of another way of indicating the presence of distortion. If we have a simple oscilloscope in addition to the audio oscillator, we have available a very sensitive method of indicating the presence of distortion, although we cannot measure it by this means. Everyone knows that if we apply the same signal simultaneously to both the X and Y deflection plates of an oscilloscope, the resulting pattern is a straight line provided only that the signals fed to the two sets of plates are in phase or exactly 180° out of phase. Any other phase difference between the two is indicated by the straight line spreading into a perfect ellipse. Now, if we apply our oscillator output directly to the X plates of the 'scope, and at the same time to the input terminal of the amplifier under examination, and then feed the signal to the Y plates from the output terminal of the amplifier, we will also get a straight line, the only proviso now being that in addition to 0° to 180° phase shift (or any multiple of these) the amplifier must be free from distortion. Conversely, if we do this, and find that a straight line results, we know that the amplifier is distortionless. Now this pattern on the 'scope is nothing more than a curve or graph, in which deflection in the horizontal direction represents amplifier output. If the amplifier is distortionless, the output voltage will be strictly proportional to input voltage, and the "curve" will be a straight line. This is what is meant when a device is referred to as "linear." If, on the other hand, the curve departs in the slightest degree from linearity, the device is said to be non-linear, and we know at once that the output voltage must be a distorted version of the input voltage. It is this non-linearity that is responsible for both harmonic and intermodulation distortion, which can now be seen to be merely different manifestations of the same defect—namely, non-linearity.

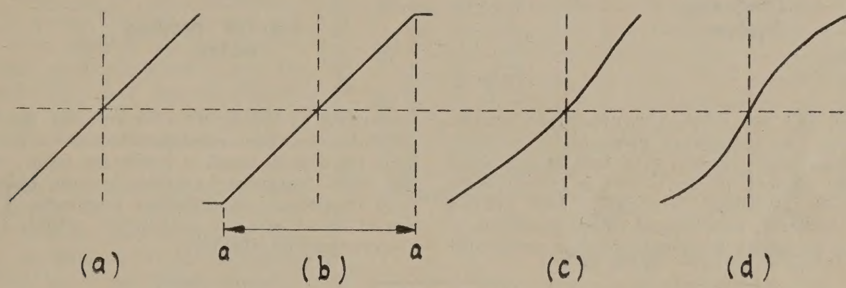


Fig. 1

The usefulness of drawing the input/output curve of an amplifier in this way is that by this means, any non-linearity is much more easily "spotted" than if we display the output voltage on an ordinary time-base. The reason for this is simply that the eye can very readily discern the difference between a line that is straight and one that is curved, however slightly, whereas it finds it difficult to observe very small differences in shape between two curved lines, such as a true sine-wave and one that is very slightly distorted. Indeed, it is quite possible to recognize the non-linearity of an amplifier which is producing no more than 1 per cent. harmonic distortion, using the input/out curve, while by looking at the output waveform, it is sometimes hard to spot as much as 10 per cent. harmonic distortion.

In Fig. 1 we have shown a number of input/output curves, illustrating various kinds of distortion. At (a) we have a distortionless amplifier working at maximum output. There is nothing on the diagram which indicates that the output is maximum for the particular amplifier, but at (b) we have drawn the curve for the same amplifier, but slightly past the overload point.

Here we can see that as long as the input voltage is not greater than a–a, the output is completely free of distortion, as shown by the perfectly straight middle portion of the curve. But as soon as the input voltage is increased above a–a, the amplifier refuses to give any more output, as is shown by the output amplitude remaining constant.

At (c), we have an amplifier which distorts at all input levels, as shown by the fact that the curve is not straight at any input voltage, however small. This unsymmetrical shape indicates even order harmonics, i.e., second, fourth, etc., and is characteristic of a poorly designed amplifier using a single triode output valve. At (d) we have a symmetrical curve which is S-shaped. The symmetry indicates that there are only odd harmonics present, and this is the kind of result one can expect to see from a good push-pull triode amplifier without feedback. The curves (a) and (b) incidentally, are typical of all good amplifiers employing negative feedback, and a push-pull output stage. Less good feedback amplifiers will give a pattern intermediate between those of (a) and (d) in which some slight curvature will be apparent, but of a symmetrical kind, indicating zero second harmonic distortion. An amplifier showing both second and third harmonic distortion in appreciable quantities will give a pattern like that at (c). Here, the S-shaped curve shows the presence of odd harmonics, as before, while the fact that the upper and lower portions of the S are not identical in shape reveals the presence of second harmonic.

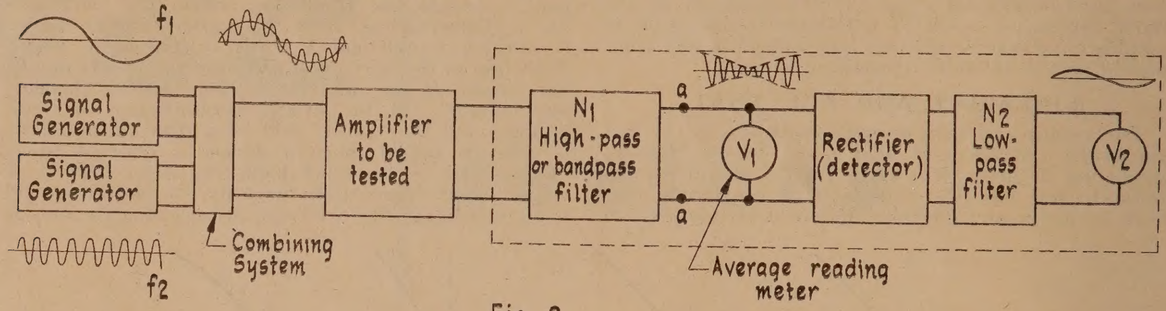


Fig. 2

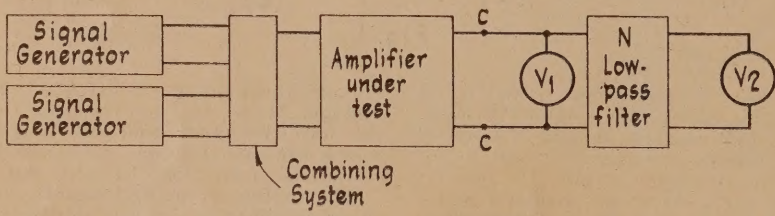


Fig. 3

MEASURING INTERMODULATION

There are a number of ways of measuring intermodulation distortion. Practically all of these depend on the use of special intermodulation analysers, one representative type being shown in block diagram form in Fig. 2.

In this method, two frequencies are applied to the amplifier simultaneously. Usually one frequency is much lower than the other, and is four times the amplitude of the higher one. Under these conditions, intermodulation shows up as a modulation in the amplitude of the high frequency tone by the low frequency one, and the purpose of the measuring equipment is to measure the degree of this modulation. First of all come the two signal generators, and some means of adding together their outputs without introducing distortion. The combined signal is fed into the amplifier to be tested, the output of which is fed to the measuring gear proper. Here, the signal passes through a high-pass filter which removes the low frequency, leaving only the high frequency, modulated in amplitude by the lower. At this stage, an average-reading meter measures the average amplitude of the high frequency tone, which can be regarded as acting as a carrier for the low frequency modulation. The modulated carrier is then detected, and passed through a low-pass filter, which removes the high frequency carrier, leaving this time only the low frequency modulation products. These are measured by a second voltmeter, which is calibrated in percentage modulation.

Another method is illustrated in Fig. 3. Here, two high frequency tones of equal amplitude, are used, and the difference in frequency is quite small. The object here is to measure the amplitude of the difference frequency, so that the measuring equipment becomes considerably simpler. In this method, peak voltage readings are made, which enables simpler vacuum-tube voltmeter circuits to be used.

It can be seen from the descriptions of these two methods, that the results obtained will depend not only on the amplifier itself, but upon which method of measurement is used. The first method, which is the one recommended by the American Society of Motion Picture and Television Engineers, and known as the SMPTE method, emphasizes the behaviour of the amplifier at high frequencies when distortion is taking place at low frequencies, while the second method, known as the CCIF method, focuses more attention on the low frequency intermodulation components arising from non-linearity at high frequencies. Naturally, in a given amplifier, both effects take place simultaneously, and which causes more grief to the listener is a matter of circumstance, depending on the type of programme material, among other things. As a result, the complete testing of an amplifier should entail both methods of intermodulation measurement, together with harmonic distortion tests at a number of frequencies. The only thing to be inferred from the above statement is that intermodultion measurements do not tell the whole story, any more than do harmonic distortion measurements. In

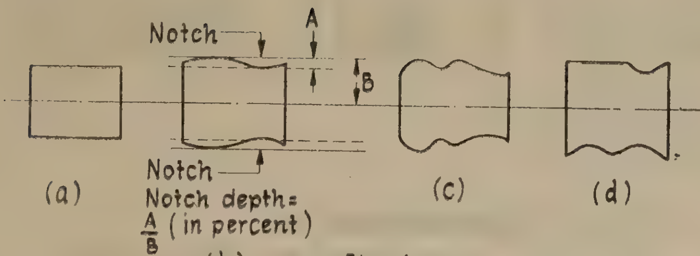


Fig. 4

material, among other things. As a result, the complete testing of an amplifier should entail both methods of intermodulation measurement, together with harmonic distortion tests at a number of frequencies. The only thing to be inferred from the above statement is that intermodulation measurements do not tell the whole story, any more than do harmonic distortion measurements. In spite of this, it has been abundantly proved that intermodulation tests, by whatever method they may be made, do give a better answer than harmonic distortion, to the question of "Is this amplifier good enough to be called 'High Fidelity' or not?"

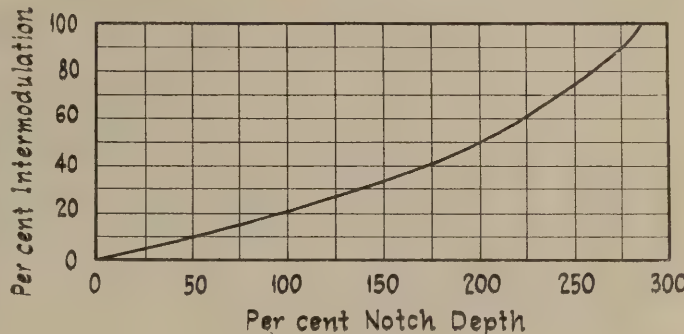


Fig. 5

THE SIMPLE 'SCOPE METHOD

This method is described by its originator Le Bel in *Audio Engineering,* and by Langford-Smith in the latest edition of the *Radiotron Designers' Handbook.* In it, the two voltages of different frequencies are applied to the amplifier as usual, and the amplifier output is passed through a high-pass filter which removes the lower of the two frequencies, just as in the first method described above. The modulated high frequency tone is then applied to the Y plates of the 'scope, while the time-base is synchronized at the frequency of the lower of the two tones. When this is done, an output containing no intermodulation at all, shows as a plain band, as at (a) in Fig. 4, but if intermodulation is present, various notches appear in the pattern. Le Bel has worked out experimentally a method of evaluating the intermodulation distortion by measuring the depth of the notches. If the pattern is symmetrical, as in Figs. 4 (b) and (c), only the notches on one side of the horizontal centre-line are counted, but if the pattern is unsymmetrical, like that in Fig. 4 (d), one counts all the notches.

To take a measurement, the notch is measured, as in (b) as a percentage of the peak output. The percentage is then applied to the graph of Fig. 5 to obtain the percentage intermodulation. It will be noticed that this curve is linear up to 100 per cent. notch depth, which corresponds to 20 per cent. intermodulation. Higher percentages of notch depth can obviously be obtained only by adding the percentage depths of several notches, since any one notch cannot be deeper than 100 per cent.

RESULTS OF INTERMODULATION MEASUREMENTS

The superiority of intermodulation testing as a method of showing up the deficiencies of amplifying equipment is very clearly shown by Fig. 6 which illustrates the sort of thing that is quite commonly found when reasonably good amplifiers are subjected to both intermodulation and harmonic distortion tests. Curve A gives the harmonic distortion, and B the intermodulation distortion figures measured on the same amplifier. According to curve A, the harmonic distortion varies almost imperceptibly from a little under 2 per cent. to a little over 2 per cent. as the output voltage is increased from 35 to 45 volts, and is still well under 3 per cent. at an output of 55 volts.

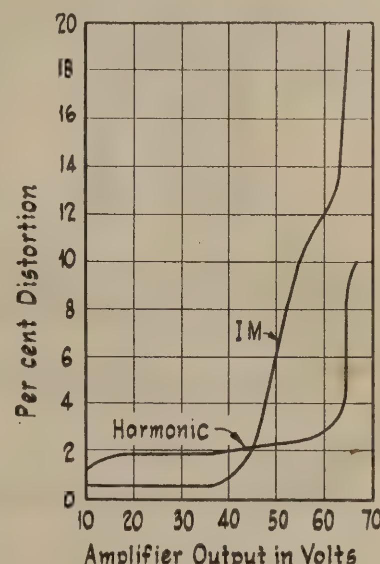


Fig. 6

But the intermodulation curve shows that at about 37 volts the IM distortion takes a sudden upward trend, and has reached 10 per cent. at 55 volts. If we rated this amplifier as giving an "undistorted" output up to 3 per cent. harmonic distortion—and not so long ago this would have been classed as a conservative rating—the rated output would be set down as 62 volts. But if,

(Continued on Page 47.)


tecnico

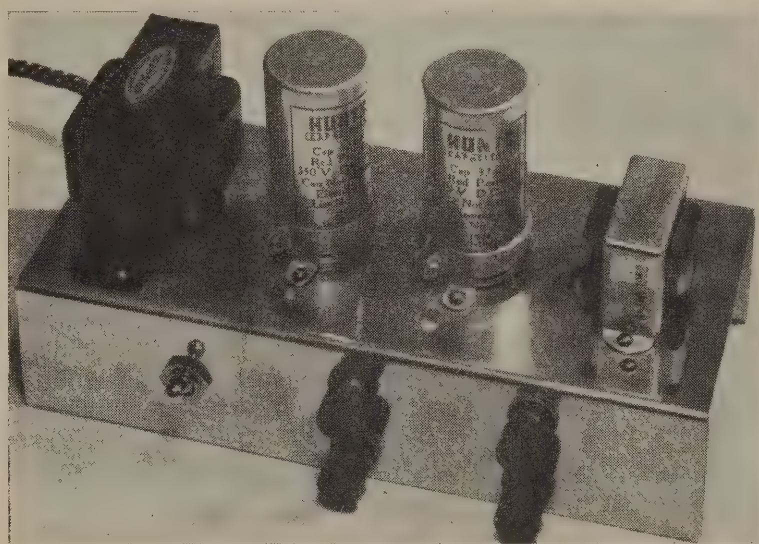
Operating Battery Sets from the Mains

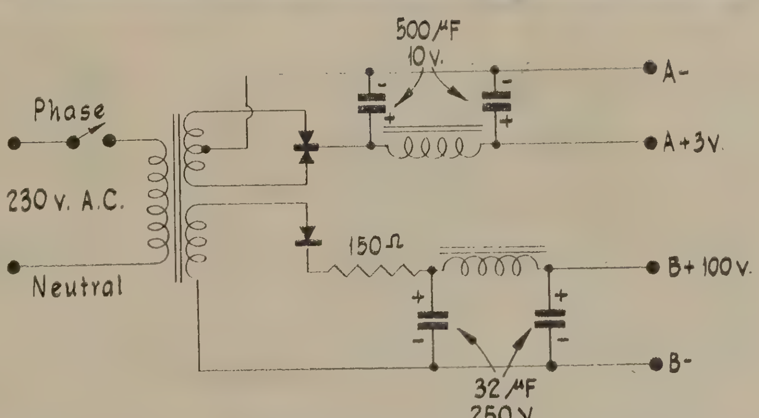
For some time past we have been aware of the necessity for a power supply, working from the A.C. mains, which would enable battery receivers to be used without running down their batteries. This article describes such a power supply, which has been designed with special reference to a battery receiver which appeared in these pages some little time ago, but will be found to have much wider usefulness than this fact might suggest.

INTRODUCTION

Earlier this year, in our January, 1953, issue, we published the design of a modern six-valve battery receiver. Readers will no doubt remember it, since it was the first receiver described in this country which used one of the modern ferrite rod aerials, such as are coming into very general use in America, to replace ordinary loop aerials in portable and other receivers. This set had its filaments wired in series-parallel, for 3-volt operation, and was designed for use with a 3v. A and a 90v. B battery. The output stage was unusual in that it employed a pair of Rimlock E141 tubes in Class B_1 in order to achieve an output of about half a watt of audio without the excessive B drain that would accompany an ordinary stage having this output. The set drew approximately 13 ma. H.T. current when not tuned to a station, and appreciably less than this when tuned to a strong local, and at low or medium volume.

Such a set as the one we have been describing has a considerably better performance than the usual run of small portable receivers, since it includes an R.F. amplifier stage, and has a large audio power output. Between them, these two features make the performance approach that of the larger A.C. operated set quite closely, with the added advantage of portability. Now if the owner of a set like this could operate it from the mains when it is not being used away from the house, it immediately becomes a much more attractive proposition. It can be used at home instead of lying round gathering dust from one summer to the next, or alternatively, it can be used without ruining its owner by eating up batteries at a high rate of speed.





Above: Photograph of the complete battery eliminator, and below, the circuit diagram.

SUITABLE FOR MANY BATTERY SETS

Accordingly, a small A.C. operated power supply was designed in our laboratory, which would power not only the receiver in question, but any set with filaments wired for 3 volts, and requiring a 90-volt B battery. Unfortunately, there turned out to be no standard commercial transformer available which was suitable for the job, so we had to have a transformer specially made. This should not constitute a difficulty for any would-be constructors, since any of the manufacturers who specialize in transformers would be able to supply one to the required specifications. Likewise, suitable metal rectifiers are readily obtainable. Some readers might wonder why it is we have not specified a low-tension winding and rectifier that would give a smoothed output of 1.5 volt. The rea-

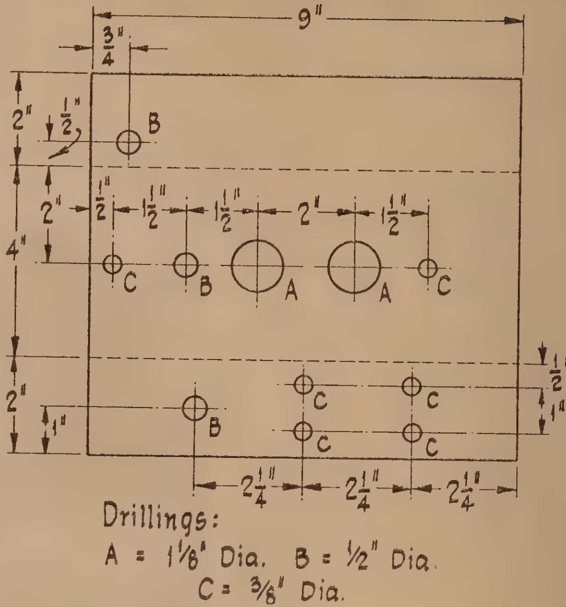
son is quite simple. The lower the voltage, the more difficult it is to obtain satisfactory smoothing of the A voltage, so that there is considerable advantage in obtaining a higher voltage. It is for the same reason that the A battery eliminator portion of the circuit uses a full-wave metal rectifier instead of a half-wave. The circuit is exactly similar to that of a full-wave valve rectifier. Two separate rectifiers can be used or one can have a full-wave one made up. If separate rectifiers are used this does not make any difference to the circuit, since they are merely connected back to back. One word of warning is necessary, however, with regard to the method of marking the polarity of metal rectifiers. It is standard practice to mark in red the terminal which corresponds to the cathode of a valve diode. This is quite a sensible arrangement, because when the rectifier is in use, the red terminal will be the one which delivers a positive output voltage.

SPECIFICATION OF PARTS

The power transformer is as follows. The low-voltage secondary delivers 3.5 volts A.C. each side of the centre-tap. The high-voltage secondary gives 110 volts A.C. at 30 ma. The low-voltage winding should be able to deliver a maximum of half an ampere. This will take care of the filaments of the largest battery sets likely to be built with the modern low-drain valves.

The smoothing choke in the A supply circuit is a standard item of unspecified inductance, but billed in the catalogues as a "Vibrator A choke," having a D.C. resistance of 0.6 ohms. It was hoped that sufficient A smoothing might be obtained by simply using enough capacity, amounting to some thousands of microfarads, and doing away with the choke, but when this was tried, it was found that the least expensive way to do the job was to use the choke after all, since enough 500 μf. electrolytic condensers to do the job on their own cost more than the choke and only two condensers. For some sets, which have a good bass response, it may be found that the hum level is a little too high for comfort. If this is so, a third 500 μf. electrolytic connected across the output of the A supply will reduce it considerably. There is no difficulty at all about getting a smooth enough B supply with the circuit shown, but we do not recommend skimping the smoothing condensers; 8 or 16 μf. condensers will definitely prove insufficient.

Only one other point remains, and that is that the negative ends of both A and B supplies have been left floating, neither being connected to the chassis. The purpose of this is to take care of those sets which may have peculiar connections inside, which prevent one from earthing one or other of the supplies directly to the chassis. In the six-valve set mentioned earlier, for instance, back bias was used, and this means that the negative H.T. terminal is not earthed directly to the chassis, but through the back-bias resistor. If the supplies are both left floating in this way, and are simply attached to the appropriate battery leads that issue from the receiver, no trouble of any sort will be encountered, whatever the circuit of the set. It is essential, of course, to make sure first of all that the set's filaments are wired for 3 volts. Most sets wired for 1.5 volts can easily be re-wired for 3 volts, but if you are in any doubt about how to go about it, you should obtain the circuit of the set, if you do not already know it, and see from that whether the change is easily possible. For example, if the set has a 3S4 or DL92



Working drawing for the chassis.

output stage, it will be a simple matter to re-wire its filament for 3 volts. The rest of the job amounts to finding a suitable series-parallel arrangement for the remaining tubes, which in all probability will be 50 ma. 1.4v. types. If there are only three of them, it will be possible to put two in series, and put a resistor in series with the remaining one. If there is room on the chassis, a good plan would be to install an extra valve socket, and use a spare valve as the dropping resistor. For instance, a spare 1S5 could be plugged into the socket, and its filament used as the dropping resistor to supply the one working in the set. Then, if the latter breaks down, except by filament failure, the cure will simply be to change over the positions of the two tubes!

CONSTRUCTION

The photograph and chassis diagram show the simple way in which the original was built. There is no need to put ends in the chassis unless they are particularly wanted. Terminals were used for bringing out the two supply voltages, as this made the unit more flexible. However, if it is to be used with only one particular set it might be more convenient to replace the terminals with a plug and socket. The two large cans are the 32 μf. electrolytic condensers, and the choke above the chassis is the B choke, the A choke being mounted under the chassis with the 500 $\mu\mu$f. electrolytics. For convenience an on/off switch was mounted on the chassis, but this can be omitted if desired.

"R. & E." TV COURSE

Intending students are reminded that the Wellington course of ten lectures commences on 7th September at 7.30 p.m. in the N.Z.E.I. Rooms, Willis Street. Registration fee £4 4s. As accommodation is limited, intending students should make early application.

Book Reviews

Principles of Television Servicing, by C. V. Rabinoff and M. E. Wolbrecht. Publishers, the McGraw-Hill Publishing Co., Ltd., London. Price (in United Kingdom), 44s.

This is another of the series of American texts which are being marketed in sterling countries by the London branch of the McGraw-Hill book company. This firm has established a reputation, over a long period, for excellently written and produced books on scientific and technological subjects, and the present example is no exception. Naturally enough, the book concerns itself solely with American transmission standards and receiving practice, no mention being made of receivers for other systems. It was written for the American radio technician, and aims at giving him a practical insight into television servicing without any "theory" at all. The authors assume that the reader is grounded in the principles of valve circuits, and that he has an understanding of the principle of the superheterodyne receiver, but do not even expect him to be familiar with ordinary radio servicing technique. They take him through the receiver from the beginning, after a short introductory chapter on basic principles, and after further chapters describing the external features of a wide selection of commercial receivers. The emphasis throughout is on servicing, and the authors have assumed the possession of three basic instruments only, an oscilloscope, a vacuum-tube voltmeter, and a frequency-sweeping signal generator covering frequencies from zero to over 200 mc/sec. Such generators are readily available in the U.S.A., and are designed for the conditions that obtain in that country with regard to television channels, normally used intermediate frequencies, and so on.

As each portion of the receiver is described, reference is made to circuits which have been used in actual receivers, both old and new, and the circuit diagrams are very liberally illustrated with reproductions of actual 'scope presentations of the waveforms to be found at various points. The explanations of circuit functions are almost entirely "practical" in nature, and avoid almost completely descriptions couched in technical terms. The main criticism of the presentation is that very little description is given of basic mechanisms as such. While the book contains more in the way of detailed commercial circuits than this writer has previously seen in one volume, it is distinctly lacking in such explanations as give the reader an understanding of basic circuit *types* as against showing him how to deal with specific examples of manufacturers' actual arrangements, which are always more complex than the fundamental circuits from which theirs are developed. It would appear to be more useful to someone who already has a good knowledge of TV fundamentals, and who is now concerned with gaining some detailed knowledge of the methods of American manufacturers, than to the almost completely non-technical reader to whom the book is addressed. Nevertheless, the book is an excellent one in many respects, and contains a great deal of useful reference material, while its recommendations concerning servicing methods are to be recommended to anyone who expects to be active in this field.

The Wireless and Electrical Trader Year Book, twenty-fourth edition; published by the Trader Publishing Company, Ltd., London.

The *Wireless and Electrical Trader* is a fortnightly trade paper published in London for the radio and electronic industry of Great Britain. It has a short technical section, but it is almost entirely devoted to matters concerning the trading activities of manufacturers, wholesalers, and retailers. It makes possible very interesting comparisons between the industry in Britain and our own in New Zealand, but up till now, its pages, understandably enough, will not have held much that is of practical concern to the radio trader in this country. However, with our own industry leaning more and more towards that of Britain, and with the possible advent of television, in which activity we can be expected to take a considerable practical interest in our counterparts in Great Britain, we should welcome the "Traders" annual handbook. This is a mine of information about the radio trade in Britain, and contains much that will be useful to many of us here. It contains a directory of the principal trade organizations, specifications of all 1953 models of radio and television receivers (including prices), addresses of all radio and domestic electrical manufacturers, agents and distributors, and radio and electrical wholesalers, a directory of proprietary names, and a classified buyers' guide, as well as a wealth of information on British components and built-up equipments, under the guise of advertising. Another most useful feature is a list of all current British valves and TV cathode ray tubes, with their most important characteristics and base connections. Altogether this is a most useful volume for those wishing to keep up to date with the British radio industry.

BINDERS FOR "R. & E."

These are available to hold 12 issues—price 5s. 6d.

Electron Coupling

By PHILIP STOWELL

Just over two decades ago, J. B. Dow, of the United States Navy's Bureau of Engineering, published his work on stable oscillators in two articles appearing in the *Proceedings of the I.R.E.*, and the magazine *QST*. They describe electron coupling, which is still, under the name of "the electron-coupled oscillator" perhaps the most currently used means of obtaining stability with variable frequency oscillators. Judging from the descriptions in various texts on articles, however, it would sometimes appear that the fact that Dow had enunciated a principle and devised a method of giving it effect and had discovered coincidentally a further means of improving stability, has been largely forgotten. The term "electron-coupled" is often used loosely tied to the word oscillator, instead of being a mode of coupling which may be applied to many classes of oscillator circuits. Dow himself shows Hartley, Colpitts, and TNT oscillator circuits with their outputs electron-coupled to the load; while in recent years such diverse circuitry as multivibrators and phase-shift oscillators have been profitably electron-coupled. Again an indiscriminate assortment of oscillators employing beam tubes and pentodes in feedback circuits are described as enjoying the benefits of Dow's methods of stabilization, despite the fact that Dow went to some pains to point out that a fully shielded tube was required, run as a true tetrode. Indeed, at times it seems that any oscillator employing a multi-element tube with a tuned anode circuit is classed as a Dow oscillator.

The facts are these: Dow relates that he experimented with various oscillators both of the feedback and negative resistance types and found them all wanting in terms of frequency stability inasmuch as that the load, being coupled to the frequency determining tuned circuit, caused the frequency to vary whenever it was altered slightly, deliberately or accidentally. He reasoned, quite justifiably, that if he could transfer power to the load without reasonable alterations in the load impedance being reflected back, that the worst obstacle in the way of stability would be overcome. It occurred to him therefore to run the first three electrodes in a tetrode valve as the elements of a normal triode oscillator and examine whether the waveform of the anode current was sufficiently influenced to excite another tuned circuit placed in it. In this conjecture he was singularly successful and that formulation of an inherent weakness in a system and the devising of a means to obviate was no mean achievement.

Evidently aware of the constant-current characteristic of the tetrode valve, i.e., the anode current's independence of the anode potential within wide limits, he implied that provided the anode swing remained within those limits the placing of a tuned circuit in the anode lead could be effected, from which power could be coupled out, without the mean value of the anode current being affected by the instantaneous value of the high frequency potential across the load. The small, random, changes in the load impedance were now very effectively isolated. Essentially, the load was no longer coupled electrostatically or electromagnetically to the frequency determining portion of the circuit, and was thus no longer an effective part of it; any possible changes could now affect only the valve constants.

Amongst the obvious consequences of this development was that since the frequency determining tuned circuit no longer had to handle power in any quantity the C/L ratio could be greatly increased raising the effective Q and thus the natural stability of the oscillator at the expense of power transfer efficiency, now no longer required. Another benefit appeared from this, since the tank circuit C might now be made very great in comparison with the oscillator valve input capacity, which changes with temperature and supply voltage variations, so that secondary frequency stability, from two other adverse effects was obtained in part.

At the same time coupling to the valve elements could be greatly reduced where large outputs from the oscillator stage were not required with a further improvement with respect to temperature and supply voltage changes.

Again, just as the C/L ratio could be improved in the control circuit for the sake of stability, so the L/C ratio of the output circuit could be raised to confer the two advantages of increased dynamic resistance, and improved power transfer efficiency from tank to load, since now only sufficient Q to maintain a substantially sinusoidal current in the load was required in the output circuit.

Although the overall efficiency of the tetrode oscillator was not found much better than for a triode, owing to increased cathode loss and the extra screen loss in the former, the loss of D.C. watts at the screen was much more acceptable than the loss of H.F. volt-amps at the control grid. The tetrode proved to have a much higher power sensitivity, requiring considerably less of its own output to drive itself than the equivalent triode.

Subsequently the waveform of the anode current was found to be so rich in harmonics that further improvement in the isolation could be had by operating the anode circuit at two or three times the input frequency with little loss in efficiency. This is invariably the practice today in lower power master oscillators whose output is electron coupled.

However, this is only part of the story: Dow goes on to explain how, while measuring the frequency shift that occurred with voltage changes on the "inner and outer anodes" as he described the screen grid and anode, he discovered that whereas increasing the screen potential lowered the frequency of oscillation, increasing the anode potential raised it. Plots of curves taken to show the rate of change of frequency with voltage about various mean values showed that ratios could be chosen so that the slopes of the curves were equal and opposite, and such that a variation in frequency one way about to be caused by a change of anode potential could be equally offset by the proportionate change in screen potential when the two electrodes are fed from the same supply.

In practice, while this point may be plotted, it is usually determined experimentally. Naturally the particular value for any valve may not correspond with maximum efficiency, although the positioning of the cathode tap and the value of the grid-leak may be varied, in some cases to secure coincidence, and satisfactory operation in all cases. If this smacks of trial and error then the reader must remember that setting up an oscillator is always carried out finally in this fashion after the initial paper work (see Terman *Radio Engineering*).

Perhaps the thing which discourages some from such an approach is the necessity for a consistent technique, accompanied by a written record of the results, which never do seem to stay in the memory for long enough.

A very fine electron coupled version of the Hartley circuit has been developed by the R.C.C. Co. and is featured in their Air Cooled Transmitting Tube Manual TT3, which is readily available. It is designed about the type 802 pentode, but could be scaled down to suit any short grid based, well shielded H.F. pentode of the more modern type.

Where a filamentary type valve is employed and it is not convenient to place H.F. chokes in the filament leads, the screen must be run at H.F. potential, in which case it is necessary to neutralize the stage. In a discussion of this and the alternative of the employment of a pentode valve with the suppressor at zero potential to H.F. as an internal shield, Dow points out that the ability to stabilize against supply voltage changes is lost in the latter case. It might be added that mu-g3 for most pentodes is probably too low in any case to produce sufficiently effective shielding; hence tetrode operation of a pentode is always to be desired. Beam tubes and pentodes with internally connected suppressor grids are to be avoided in oscillators where stability is of first importance.

Where an effective voltage regulated power supply and ancillary class "A" buffer stage are available there is probably little to choose between electron coupling the output from a standard Hartley or Colpitts circuit, and the employment of the Franklin, Clapp, or Grisdale triode oscillators. However, in portable and mobile equipment where efficiency and space are at a premium, the electron coupled version, combining oscillator and buffer action in the one valve, is vastly superior. At the same time it should be realized that it is an indisputable fact that if electron coupling is applied to any of the special triode oscillators mentioned above their performance would be further improved.

CORRECTION

In the article on page 7 of the May, 1953, issue of *Radio and Electronics* there was an omission in the circuit diagram. This was the circuit of the "V.F.O. for the V.H.F. Transmitter," and the blocking condenser between the plate of V_8 and the pi-section output coupler was left out. The condenser should have a value of 100 $\mu\mu$f. and should be a mica or silvered mica type. In addition, the connection shown between C_{12} and the screen lead of V_8 is an error and should be omitted.

SHOES and SHIPS

"The time has come," the Walrus said
"To talk of many things. . . ."

By Special Arrangement with the Walrus

So accustomed do we radio folk in New Zealand get to seeing American and British radio equipment and components that we are apt to forget there are other parts of the world just as busy worrying about amps, ohms, and volts as we are. Every so often when some foreign gear finds its way here it attracts interest by virtue of its very difference—both in appearance and the method of approach to a problem.

Recently seen and tried were two German pieces of work, one a tape recorder for attachment to an ordinary radio and record-playing turntable and the other a three-speed gramophone motor.

The tape recorder is quite an effective instrument and very Continental in appearance. It is divided up into several different parts, all very small—the tape deck for attaching to the turntube, the amplifier, the power-pack, a small switch panel, and a microphone. All units are in-connected by a variety of very Teutonic-looking cords and plugs and are so arranged as to be easily disposed around the average radio cabinet.

The tape deck itself consists of the two spool holders, three heads—erase, record, and playback, and the drive capstan which incorporates a useful stroboscope for use with the usual 50-cycle A.C. lighting. The deck is simplicity itself and requires no complicated setting-up procedure, the capstan just pushes onto the centre spidle of the gram motor while the rest of the weight is taken on two adjustable legs which rest on the motor-board.

The amplifier is not much bigger than the average alarm clock and houses two valves and associated circuitry in conjuction with some very well made switches. This amplifier, it should be noted, gives only the initial amplification, the remainder being provided by the audio section of the radio set itself. However, it does include the wipe-out oscillator which is no mean feat in that confined space. The power supply is much the same size and is suitable for either 110 or 230 volts. The microphone looks quite an innocent looking crystal type mounted on a small pedestal; but it packs a power of punch—in short it accommodates two diminutive valves with their wiring and two 4.5-volt flat batteries. This is the microphone pre-amplifier and despite its small proportions doesn't appear a bit cramped. The radio set should be provided with pick-up input terminals and a tap for connecting to the voice-coil side of the output transformer (the usual extension speaker terminals). This latter connection is necessary for recording purposes. The whole set-up works quietly and without any fuss and the results obtained from it seem to be quite remarkable—there is a notable absence of "wow" (after all a gram turntable should make a pretty good flywheel) and the reproduction is crisp and clean. The Walrus has heard many a full-grown tape recorder which could be put to shame by this little attachment. The tape spools are small ones, holding about 600 feet of tape and while it was only tried at a turntable speed of 78 r.p.m., it would no doubt function quite well at 33⅓.

The second thing examined was the German three-speed motor and this seems to be something really good. It does not rely on jockey pulleys, etc., to get the speed reduction, but is set up with a proper little gear-box and gear shift lever. The gears are beautifully cut from a laminated fibre—probably bakelized linen, and should prove quiet and positive in action. The motor itself is the conventional squirrel cage type of generous proportions and is provided with a centrifugal governor, thus it is possible to select any of the the three speeds by the gear-change and vary the speed either side of the particular one selected by means of the governor. This latter feature is one found on few motors for this sort of work.

To those who happen to see this motor, the Walrus would say take careful note of the gear-box and gear-change—it's fascinating to use besides which it might prove cheaper to let the girl friend learn on this rather than the car!

However, it is interesting to see how countries well removed from us go about jobs in a different way but arrive there just the same.

No. 8

LABORATORY NOTES from BEACON RADIO LIMITED

THE TESTING OF RADIO POWER TRANSFORMERS

A number of methods are available, no one of which gives the complete answer. The serviceman usually has limited means at his disposal but a wealth of valuable experience to fall back on. Actual measurements that may be made easily are:

(a) A measurement of primary and secondary voltages.

(b) A check on the primary input current when no load is connected to the secondary.

Unless something very serious is wrong neither of these checks will definitely indicate a defective transformer. A suitable wattmeter will usually show if excessive no load input current means shorted turns. Often a high no load input current means a 60-cycle transformer used on 50 cycles, or a core in which the air gaps between the laminations become significant as is generally the case for a very small transformer.

A good inductance bridge which will indicate a "Q" reading will help greatly in finally deciding if the border line case has shorted turns.

Insulation break-down between windings or from winding to core may not show up on a multimeter reading. Some device which will give a high voltage at a low current, such as a 500-volt megger, will readily detect bad insulation. More elaborate high voltage testers that detect excessive insulation corona are often used.

In all, the proper testing of transformers requires knowledge, experience, and equipment. There is one test from which Beacon transformers come out with flying colours and that is the test of time.

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The "RADIO and ELECTRONICS" Abstract Service

AERIALS AND TRANSMISSION LINES

Some aerial queries—a distinction is made between the effects of inductance, where power is always returned to its source, and radiation, where the power is actually radiated. From there we proceed to the factors which are necessary for radiation, aerial sizes and couplings. Reference is made to the compromise used for the home aerial, and the effects of the half-wave dipole. Again an excellent article for the student.

—*Wireless World* (Eng.), May, 1953, p. 235

The paper described the objectives, mechanical and electrical problems and solutions, and final performance of the multiple antenna system for television and F.M. broadcasting of the State Empire Building. The project was a huge one, and some idea is given of the complexities of the system, and the design of the 200 ft. tower.

—*Proceedings of the I.R.E.* (U.S.A.), March, 1953, p. 324.

Low-loss waveguide transmission: The Bell System is interested to know whether waveguide can be used as a long distance communication in the manner in which coaxial cable or the radio-relay system is now employed. The interest is partly due to the fact that radio-wave propagation through the atmosphere becomes progressively more severely handicapped at the higher frequencies, so that the use of the spectrum above the frequency of 12,000 mc/sec. seems to need a sheltered transmission. Using the circular electric wave, theoretical heat losses of 3 db. per mile are possible. Notes on the problems involved are given.

—*Ibid*, p. 348.

Ultra-high-frequency mobile antenna: antenna gain can be obtained by stacking vertical elements and feeding them in phase, but vertical radiating elements present problems to the designer, who must fabricate means for support, and for feeding each element. The advent of mobile services in the 450 and 470 mc/sec. region demands the use of many vertical stacked elements. The design is a very compact Franklin embedded in a fibreglass tube.

—*Electronics* (U.S.A.), May, 1953, p. 181.

AUDIO EQUIPMENT AND DESIGN

A portable power amplifier: many designs are very inconvenient for carriage on buses, and the results from the assembled set far from good. The equipment described was designed to give an output of 8 watts with less than 1 per cent. distortion, and includes the turntable at the bottom of the unit. The back of the loudspeaker box hinges up to give an extended baffle to avoid bass boom. The construction of the amplifier unit is described.

—*Wireless World* (U.S.A.), May, 1953, p. 201.

A further article on designing a tape recorder: this gives the circuit diagram of a complete instrument. Mention is made of the motor starting, stopping and brake release system, the layout and methods of testing and settting up the apparatus.

—*Ibid*, p. 229.

CIRCUITS AND CIRCUIT ELEMENTS

Stability in negative feedback time-bases: negative feedback being a useful means of ensuring linearity in time-bases, is often used. Many of these systems can be classed as direct integrating types in that the voltage or current required for the application is the integration of some constant voltage used in the system. The article shows how such feedback may be applied with a view to avoiding the instability which may occur. The subject is treated mathematically.

—*Electronic Engineering* (Eng.), May, 1953, p. 192.

ELECTRONIC DEVICES

The repetitive working of photoflash tubes: the simplest method of using a photoflash tube for repetitive working is to charge up a capacitor through a resistor and discharge it through the tube by triggering the latter. This circuit has considerable limitations when high repetition rates are required. One method of obtaining larger light outputs at higher speeds is to control the flashes by means of hydrogen-filled thyratrons, but the circuit given uses only familiar valves, and will enable photographs to be taken at speeds up to 1200 frames per second.

—*Ibid*, March, 1953, p. 122.

Photo-electric printing and engraving machines: operating principles and details of two automatic stencil-cutting machines, a typesetting machine that delivers negatives instead of slugs, room-size scanners for correcting colour-separations, and a desk-top engraver for making plates. These machines are the product of much experimenting and research, and show the great advances made in these branches of photo-electric printing.

—*Electronics* (U.S.A.), May, 1953, p. 138.

INSTRUMENTS AND TEST GEAR

Frequency and wavelength measurements become increasingly difficult when the highest frequency boundary is extended into the millimetre region. Transmission line and cavity resonator techniques become useless and the physical dimensions of the measuring circuit diminsh. With increasing frequency electromagnetic radiation is found to exhibit more and more optical properties so measurement tends to three techniques—the Boltzmann interferometer, the differential grating spectrometer, and the Michelson interferometer. These devices are described in the form used for cm. wavelengths by the authors.

—*Electronics* (U.S.A.), May, 1953, p. 184.

Frequency standards of very high precision have been available for a considerable time; but when an appreciable frequency spectrum is to be explored, existing methods are not very satisfactory, and during the war an equipment known as a frequency synthesizer was developed and is described in the article. Details are given of apparatus whereby any one of a possible 100,000 frequencies is available between 1 kc/sec. and 100 mc/sec. controlled in accuracy by a single frequency standard.

Electronic Engineering (U.S.A.), May, 1953, p. 178.

MATERIALS, VALVES, TRANSISTORS, AND SUBSIDIARY TECHNIQUES

It is becoming apparent that a new range of components must be devised compatible with transistor sizes. A modern junction transistor is of the order of 3/16th of an inch square, and its advantages are somewhat nullified if the other components are not in proportion. The low voltage and low current needed to operate the transistor, make possible almost wattless resistors and very thin dielectric capacitors the latter needing to withstand voltages of, say, 10 to 15 volts only. This opens up a new field for the manufacture of components, and the article deals with the size and shape of things to come.

—*Wireless World* (Eng.), May, 1953, p. 196.

Voltage stabilization: this article deals with the requirements of various types of apparatus, and the bibliography of the sub-

(Concluded on Page 48.)

The PHILIPS Experimenter

An advertisement of Philips Electrical Industries of N.Z., Ltd.

No. 70: Philips Germanium Diodes and their Application

Reprints of these EXPERIMENTER articles, complete with illustrations, will be mailed to any address for one year for a subscription of 5s. Application should be made to Technical Publications Department, Philips Electrical Industries of New Zealand Ltd., P.O. Box 2097, Wellington.

INTRODUCTION

One war-time electronic development that is gradually making its presence felt more and more is the germanium diode, or crystal diode, as it is often called because of its generic relationship to the "crystal detector" of earlier days. Most of us tend to regard these useful little devices as "just another diode," but there is a little more to them than that. While they can and do often perform almost any function that is usually allotted to a thermionic diode, their characteristics are rather different from those of the latter, and in order to make the most of them, one needs to know a little about them. In some applications, the mere fact that crystal diodes have no heater through which hum may be induced into the circuit makes them very much superior to thermionic diodes. Then again, in battery-operated equipment, the fact that the crystal diode has no filament makes possible arrangements which would not otherwise be practicable at all. Another advantage of the crystal diode is its very small capacity, which is distinctly advantageous in some circumstances. Then again, their very small size fits them admirably for use in miniature and subminiature equipment, for they can be tucked away in the wiring just as can a quarter-watt resistor. Their compactness, for instance, makes them excellent for use in signal-tracer probes and in certain V.T. voltmeter circuits, where they can once more supplant the vacuum diode. They are coming into increasing use in television receivers, which normally contain quite a number of diodes. Another advantage of the germanium diode is its low resistance in the conducting direction. This can be as low as 50 ohms, with only 1 volt applied to it, which compares more than favourably with the several thousand ohms resistance of many valve diodes under similar conditions.

It is hardly to be expected that all these advantages are to be obtained with no compensating disadvantages. They have one drawback compared with the thermionic diode which overshadows any others—namely, the fact that they do not have an infinite resistance in the reverse direction, as is virtually the case with valve diodes. It is because of this important difference between them that crystal diodes are not always applicable to the identical circuit arrangements to be found with valve diodes. It is true that in many cases direct substitutions can be made with little noticeable alteration in performance, but in order that the most effective use may be made of them, the characteristics of the various types of germanium diode should perhaps be treated in some detail.

TYPES OF GERMANIUM DIODE

Arising from the fact, already mentioned, that germanium diodes do conduct slightly in the reverse direction, whereas a good vacuum diode does not at all, we have another important practical difference between the

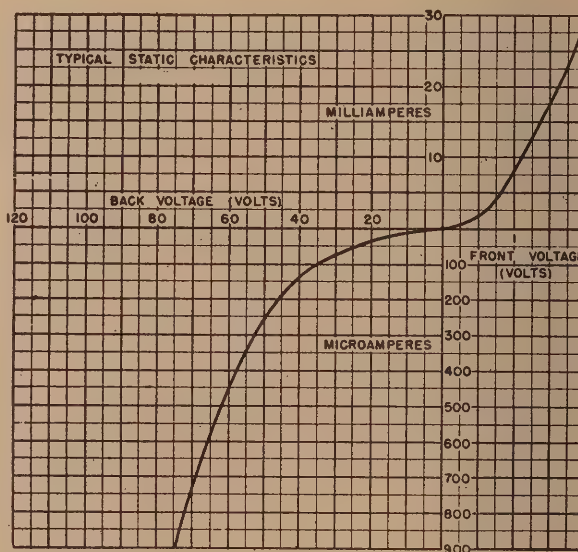


Fig. 1.

two basic types. Germanium diodes are made in quite a wide variety of types, whereas vacuum diodes are, in the main, very similar in characteristics. For example, the characteristics of the diodes in the Philips range, EB34, EBL31, EBF42, etc., are all esssentially the same in their characteristics. The EA50 and EB91 are about the only ones that differ appreciably from the others, and the difference lies mainly in the fact that these last two types are made with smaller spacing between the cathode and anode. This gives them a lower resistance than the others, and makes them more suitable for such things as television signal detectors, where the conventional diodes would have a very low rectification efficiency on account of their resistance being high compared with the load resistors that are normally used. Here it should be remembered that a rectifier can only be 100 per cent. efficient if its resistance in the forward direction is zero, and that in the reverse direction is infinite.

Germanium diodes, on the other hand, are made in a large number of different types, each of which is more suited to one particular class of job that any other. Some, for example, are selected to have a particularly low forward resistance. These are the best types to use for wide-band detector circuits, as in television, and for certain meter rectifier applications. It often happens that when a low forward resistance is required, the achieve-

ment of a very high back resistance is not so important. The Philips germanium diode type OA60 corresponds to this description. In other applications, such as D.C. restoration circuits in television receivers, the prime requirement is for a very high back resistance, coupled with as low a forward resistance as possible. Such a diode is the Philips OA61. Another requirement which has to be met in rectifier circuits is that of being able to stand up to a given voltage in the reverse direction. Valve diodes are, in general, limited only by insulation and flash-over in this respect, but crystal diodes are more severely limited, because if the reverse voltage exceeds a particular critical value, the rectifier breaks down, and never regains its previous characteristics. Accordingly, some germanium diodes are made with a specially high reverse voltage rating. The Philips OA52 and OA55 are of this type. In addition to these, there are general-purpose types, such as the OA50 and OA56.

It might be thought from the above, that the application of these diodes is a matter of some difficulty, but such is not the case, if the circuit conditions are known under which it is proposed to use a given type, provided that the user is aware of the capabilities and limitations of each type. It is the purpose of this article to provide Experimenter readers with all the information they might require concerning Philips germanium diodes, and to illustrate their use by means of typical circuits.

CHARACTERISTICS AND RATINGS

In tabulated data, manufacturers usually specify three main characteristics of germanium rectifiers. These are:

(1) Turn-over voltage.

(2) Minimum forward current at a given positive input voltage (usually + 1 volt).

(3) Maximum reverse current (at a variety of negative voltages).

The first of these requires some explanation. In Fig. 1 is shown the characteristic curve of a typical crystal, the OA50. It is a plot of current passed against voltage applied, and the voltage scale extends from high negative values to moderate positive ones. The curve is a static characteristic. That is, it depicts the behaviour when direct voltages are applied to the diode. The part of the graph to the right of the vertical current axis represents a positive voltage, applied in the direction in which conduction is easiest, and corresponds exactly to placing a positive potential on the plate of an ordinary diode. The portion to the left of the current axis shows the current which flows when the voltage is applied to the crystal in the reverse direction, i.e., the direction which, in a vacuum diode would result in no current at all.

This latter portion of the curve is never given for a vacuum diode, because the current for reverse voltages is zero. Now a casual glance at the curve might lead one to expect that the diode might pass more current in the reverse direction than in the forward direction, until it is noticed that the current scale below the voltage axis is very much expanded. The reason for this is that the lower part of the curve would be so flat as to be impossible to read accurately if the current scale were the same as the upper one. In the example shown, the lower current scale is expanded 20 times compared with the upper one.

The fact that the graph is curved means that the resistance in either direction is not constant. The curve of current versus voltage is a straight line for an ordinary resistor, whose resistance is constant, but with crystal diodes as well as thermionic ones, the resistance varies according to the voltage applied to it. This is the reason why, in spite of the importance of the values of forward and back resistance, the characteristics quoted by makers of these things never state resistance figures except at particular applied voltages. To say that the forward (or backward) resistance is so many ohms just does not mean anything unless the applied voltage at which the measurement is made is also stated.

Now where the slope of the curve is small, it means that the resistance is high, and vice versa. From this, it is possible to look at the curve and make the following deductions:

(1) For forward voltages, the resistance is very high when the voltage is below $\frac{1}{4}$-volt, and becomes progressively less as the voltage is increased.

(2) At forward voltages higher than 1 volt, the curve flattens out, showing that while the resistance is not constant, it has reached a quite low value that becomes only slightly less as the voltage is increased still more.

(3) At low back voltages, the resistance is much higher than the forward resistance, but decreases gradually for a start, and then more rapidly.

At the bottom edge of the graph, it can be seen that the resistance is still decreasing, and if the graph were continued far enough, it would eventually become vertical, indicating that the resistance had dropped to zero at some high back voltage, in the vicinity of 100 volts. If the curve were taken still farther, it would turn back on itself, and slope in the opposite direction, indicating that the resistance had become negative. That is to say, decreasing the voltage would result in an *increase* of current instead of a decrease. The voltage at which the resistance becomes zero, as shown by the curve becoming tangential to a vertical line on the diagram is known as the turnover voltage. It is a most important figure, because should a higher reverse voltage than the turnover voltage be applied, the diode would break down and become ruined.

The remaining two characteristics are almost self-explanatory. The minimum forward current at a forward voltage of 1 volt is given as an indication that the forward resistance will not be less than a certain figure. For example, for the OA50, the minimum forward current at + 1 volt is 5 ma. This represents a resistance of 200 ohms. But reference to the graph, which shows the average characteristic for this type shows that the average forward current at 1 volt is 7.5 ma., which is a resistance of 133 ohms.

Just as the minimum forward current at a given voltage gives a quick reference to the forward resistance, so does the quoted maximum reverse current at given reverse voltages indicate in a quick and convenient manner the order of back resistance to be expected. Ordinarily, however, both the forward and reverse currents are considerably better in the average diode of the type than is quoted as the worst acceptable figure for that type.

The three things just discussed are properly described as characteristics of the types to which they refer, but just as with ordinary valves, crystal diodes have certain ratings which may not be exceeded if damage is not to occur. The ratings usually given are as follows:—

(1) Maximum continuous reverse working voltage.

(2) Maximum average D.C. anode current.

(3) Maximum recurrent peak anode current.

(4) Maximum forward surge current.

The definition of turnover voltage gives a clue to

(Continued on Page 26.)

the first of the above list of ratings. Usually, the greatest allowable D.C. reverse voltage is about 80 per cent. of the turnover voltage. Usually, however, we are more interested in the maximum A.C. voltage that can safely be applied to a given type. For safety, it is as well to use the same figure for the peak inverse voltage under A.C. conditions. As a practical illustration of this, consider an ordinary shunt rectifier or D.C. restorer, which is much the same thing. The input condenser charges up to almost the peak A.C. input voltage in the reverse direction, so that we have not only the A.C. but a D.C. voltage superimposed upon it. Because of this, the peak reverse voltage is equal to twice the peak A.C. input voltage. If the peak reverse voltage is not to exceed the turnover voltage, therefore, the peak A.C. input voltage must not be more than one-half of the turnover voltage, and preferably not more than one-half the rated maximum D.C. reverse voltage.

The maximum allowable D.C. current in the forward direction is quite large, for all types of germanium diode, and is in the vicinity of 40 to 50 ma. This means that they may be used as low-voltage power rectifiers for small and moderate currents. However, care should be taken, because it is not possible to work the diodes at maximum current and maximum voltage simultaneously. Unfortunately, it is not in general possible to give ratings for this type of service, so that each application must be considered on its merits.

The maximum recurrent peak current rating is intended to apply to applications in which the diodes are used to pass unidirectional pulses. Of course, rectifier service also comes under this heading. The rating is similar to the peak current rating of ordinary power diodes, which have to pass a much greater peak current than average current, when they are used with a condenser-input filter.

The maximum forward surge current for all types is between 400 and 500 ma. This represents the maximum current that can be allowed to flow only once, and for a short period, without permanent damage to the rectifier. It does show, too, how robust these rectifiers are. They can take an overload, momentarily, of over ten times the maximum allowable direct current. In most applications, however, the question of exceeding the ratings does not occur, and the most important characteristics which determine which is the most suitable type for a given application are the forward and backward resistance. For instance, where crystal diodes are to be used as signal rectifiers in very high-impedance circuits, the back resistance is much more important than the forward resistance. But several types have a high

(Concluded on Page 48.)

TUBE DATA—Receiving Tube 12AU7

By Courtesy of Brimar

Introduction: Type 12AU7 is a miniature indirectly-heated twin triode. Each triode unit is a separate structure, the heater connections only being common, with a result that it is possible to use each unit for different functions or both in cascade. The feature of a heater centre tap enables the valve to be used on both A.C. or A.C./D.C. equipment.

This report contains characteristics of the valve and details of its use as a normal amplifier, resistance-capacity coupled amplifier, oscillator, paraphase amplifier, and as a frequency multiplier.

Description: The valve comprises two triode units mounted side by side having separate heaters but common heater pin connections, and are mounted in a standard T6½ bulb and based with a B.V.A. Standard Base Type B9A.

Characteristics: Indirectly-heated oxide-coated cathode.

	Series	Parallel
Heater voltage	12.6	6.3 V
Heater current (nominal)	0.15	0.3 A

Mac. D.C. heater-cathode potential 250 volts.

Dimensions

Max. overall length .... 2 3/16 in.
Max. diameter .... 7/8 in.
Max. seated height .... 1 15/16 in.

Base Connections

Pin 1 Plate Pin 2 Grid Pin 3 Cathode	.... Second triode unit
Pin 4 Heater	
Pin 5 Heater	
Pin 6 Plate Pin 7 Grid Pin 8 Cathode	.... First triode unit
Pin 9 Heater tap	

Note: The getter is attached to the plate of the first triode unit.

Maximum Ratings: (each triode unit)

Max. plate voltage .... 300 volts
Max. plate dissipation .... 2.75 watts
Max. cathode current .... 20 mA
Max. negative control grid voltage 150 volts
Max. average grid current .... 5 mA
Max. grid circuit resistance (auto-bias) .... 1 megohm
Max. grid circuit resistance (fixed bias) .... .25 megohm

Capacities (approx.): Measured without shield.

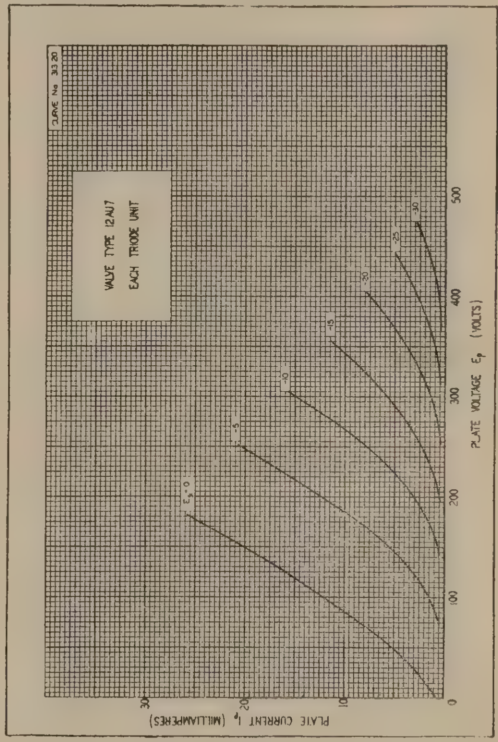
	First Triode Unit		Second Triode Unit
Grid—Plate	1.5		1.5 pF
Grid—Cathode	1.6		1.6 pF
Plate—Cathode	0.5		0.35 pF
Heater—Cathode		4.5 pF	
Grid (1)—Plate (2)		0.035 pF	
Grid (2)—Plate (1)		0.02 pF	
Plate (1)—Plate (2)		0.7 pF	
Grid (1)—Grid (2)		0.004 pF	

Characteristic Curves: Attached are curves showing:

(a) Plate current plotted against plate voltage for various values of grid voltage. (Curve No. 313.20).

(b) Plate current plotted against grid voltage for various plate voltages .(Curve No. 313.21).

(c) Mutual conductance, amplification factor and plate impedance plotted against plate current. (Curve No. 313.22).



TYPICAL OPERATING CONDITIONS

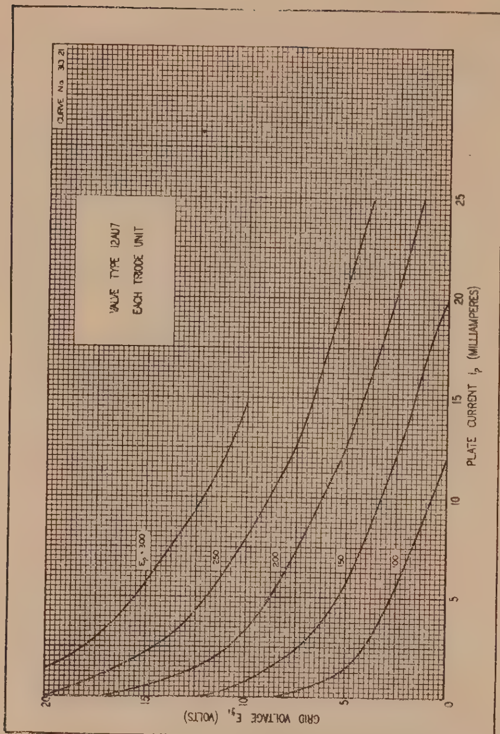
Class A Amplifier

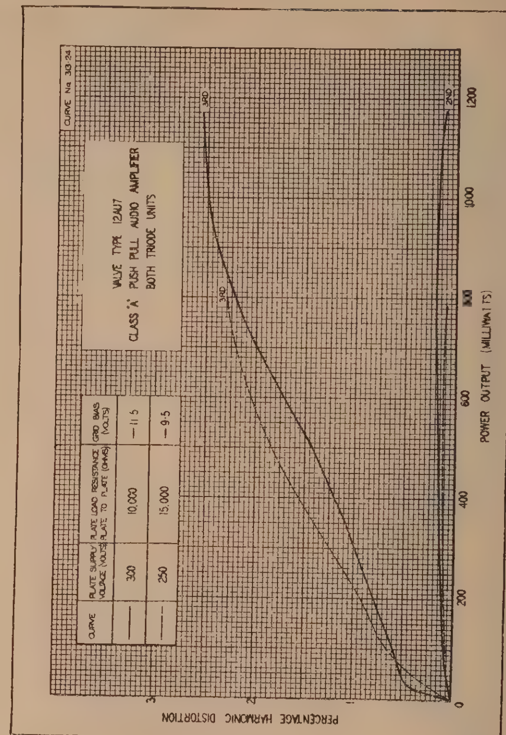
Plate voltage	100	250 volts
Grid voltage	0	—8.5 volts
Amplification factor	19.5	17
Plate impedance	6250	7700 ohms
Mutual conductance	3.1	2.2 mA/V
Plate current	11.8	10.5 mA

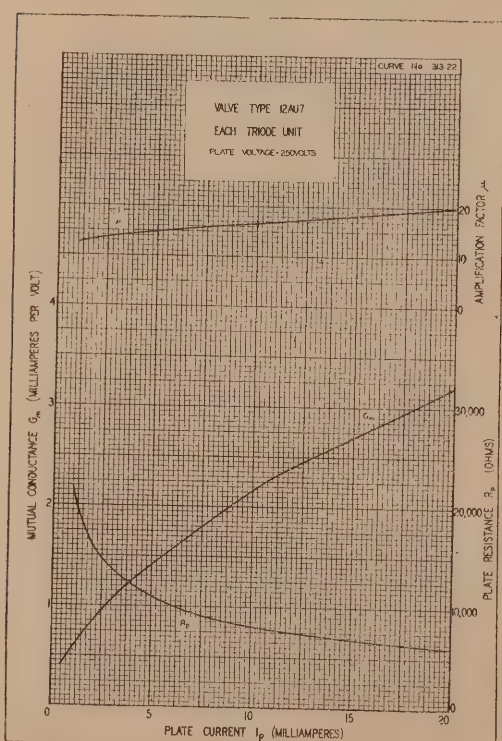
Push-Pull Class A Amplifier

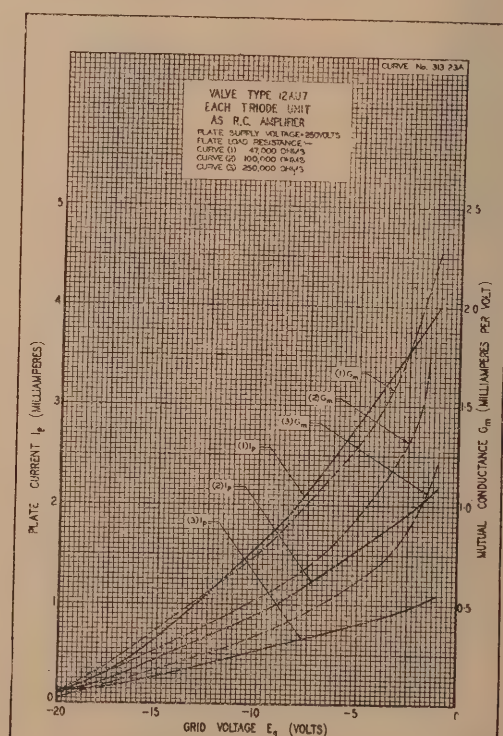
The valve is very suitable for use in a push-pull Class A stage for power outputs up to 1200 milliwatts and is capable of driving a Class AB_2 or Class B stage using valves such as a pair of 6BW6 or 5763.

A graph (No. 313.24) attached to this report shows the harmonic distortion plotted against power output for a certain set of operating conditions. The maximum outputs shown are those obtainable in Class A, i.e., up to the point of commencement of grid current.


CURVE No. 313 21
VALVE TYPE 12AU7
EACH TRIODE UNIT
E_b = 300
250
200
150
100
PLATE CURRENT I_p (MILLIAMPERES)
GRID VOLTAGE E_g, (VOLTS)


CURVE No. 313 24
VALVE TYPE 12AU7
CLASS 'A' PUSH PULL AUDIO AMPLIFIER
BOTH TRIODE UNITS
CURVE
PLATE SUPPLY VOLTAGE (VOLTS)
PLATE LOAD RESISTANCE PLATE TO PLATE (OHMS)
GRID BIAS (VOLTS)
300
10,000
—11.5
250
15,000
—9.5
3RD
2ND
POWER OUTPUT (MILLIWATTS)
PERCENTAGE HARMONIC DISTORTION


CURVE No. 313 22
VALVE TYPE 12AU7
EACH TRIODE UNIT
PLATE VOLTAGE = 250VOLTS
G_m
R_p
MUTUAL CONDUCTANCE G_m (MILLIAMPERES PER VOLT)
AMPLIFICATION FACTOR μ
PLATE RESISTANCE R_p (OHMS)
PLATE CURRENT I_p (MILLIAMPERES)


CURVE No. 313 23A
VALVE TYPE 12AU7
EACH TRIODE UNIT
AS R.C. AMPLIFIER
PLATE SUPPLY VOLTAGE = 250VOLTS
PLATE LOAD RESISTANCE —
CURVE (1) 47,000 OHMS
CURVE (2) 100,000 OHMS
CURVE (3) 250,000 OHMS
(1) G_m
(2) G_m
(3) G_m
(1) I_p
(2) I_p
(3) I_p
PLATE CURRENT I_p (MILLIAMPERES)
MUTUAL CONDUCTANCE G_m (MILLIAMPERES PER VOLT)
GRID VOLTAGE E_g (VOLTS)

Resistance-Capacity Coupled Amplifier

The valve is very suitable for use as a resistance-capacity coupled amplifier and below is a table giving a summary of useful values for three different supply voltages for one triode unit:—

(a) Plate Supply Voltage, 100 Volts:

Plate load (megohms)		0.047		0.1		0.22
Grid leak (succeeding valve (megohms)	0.1	0.22	0.22	0.47	0.47	1.0
Cathode resistor (ohms)	1800	2000	3800	4700	9500	11,500
Output voltage (peak)	11	14	15	18	20	24
Voltage gain	11	11	11	11	11	11

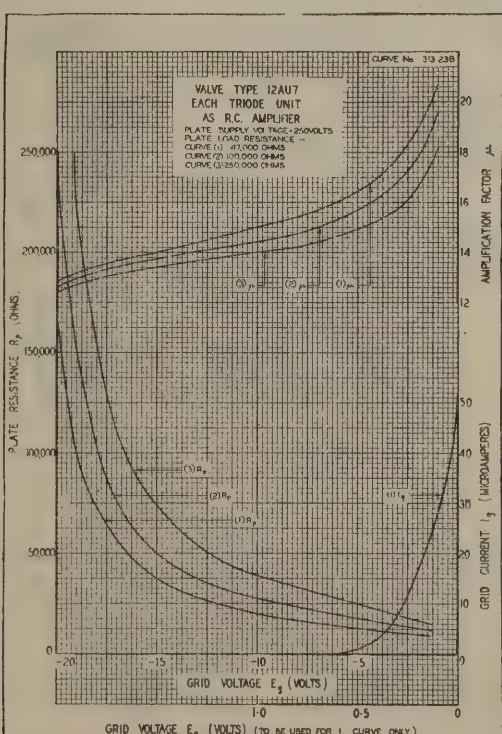
(b) Plate Supply Voltage, 200 Volts:

Plate load (megohms)		0.047		0.1		0.22
Grid leak (succeeding valve (megohms)	0.1	0.22	0.22	0.47	0.47	1.0
Cathode resistor (ohms)	1200	1400	2800	3600	8300	10,000
Output voltage (peak)	26	29	33	40	44	54
Voltage gain	12	12	12	12	12	12

(c) Plate Supply Voltage, 300 Volts:

Plate load (megohms)		0.047		0.1		0.22
Grid leak (succeeding valve (megohms)	0.1	0.22	0.22	0.47	0.47	1.0
Cathode resistor (ohms)	1200	1500	3000	4000	8800	11,000
Output voltage (peak)	52	68	68	80	82	92
Voltage gain	12	12	12	12	12	12

A graph is attached to this report which shows the relationship between the various valve parameters under conditions of resistance-capacity coupling. This graph (No. 313.23) is taken at a plate supply voltage of 250 volts with three values of plate load resistance (viz.:—100,000, 220,000, and 47,000 ohms) and plots the plate current, amplification factor, mutual conductance and plate impedance against grid voltage. From this graph the correct grid bias (cathode resistor) can be obtained, the stage gain can be calculated and an estimate made of the distortion. The graph is not drawn beyond the limits of the commencement of grid current or around the grid cut-off region.



Below follows a description of the method of using this graph. If, for example, it is desired to use a valve at a supply voltage of 250 volts, a plate load of 100,000 ohms and a succeeding valve grid leak of 470,000 ohms, then to determine the grid bias an inspection of the graph indicates a relatively linear portion of the curve of plate current/grid voltage over the range of —1 to —11 volts, the mid point being —6 volts. At this point the plate current is 1.4 mA, hence the cathode resistor should be 4250 ohms. The peak input voltage is 5 volts and the r.m.s. input 3.5 volts. Following the grid bias voltage upward it is evident that with a plate load of 100,000 ohms, the amplification factor is 15.4, and the plate impedance is 19,000 ohms. The plate load is effectively in parallel with the succeeding valve grid leak as regards the signal, but not as regards the plate current, hence the effective signal value of the plate load is 100,000 ohms in parallel with 470,000 ohms, or is 82,000 ohms. The stage gain is:

$$\frac{\mu R_p}{R_p + r_p}$$

or, in the above case:

$$\frac{15.4 \times 82{,}000}{82{,}000 + 19{,}000} = 12.5$$

The peak input voltage above was 5 volts, hence the peak output voltage will be this figure multiplied by the stage gain, or 62.5 volts r.m.s.

An estimate of the distortion may be made by calculating (from the graph as above), the stage gain at the extremes of grid bias; in the example the stage gain at 1 volt is 17 and at 11 volts is 10.5, hence the positive peaks of the signal output will be 37 per cent. less than the negative, and the distortion in the output will be approximately 12 per cent.

(To be continued.)

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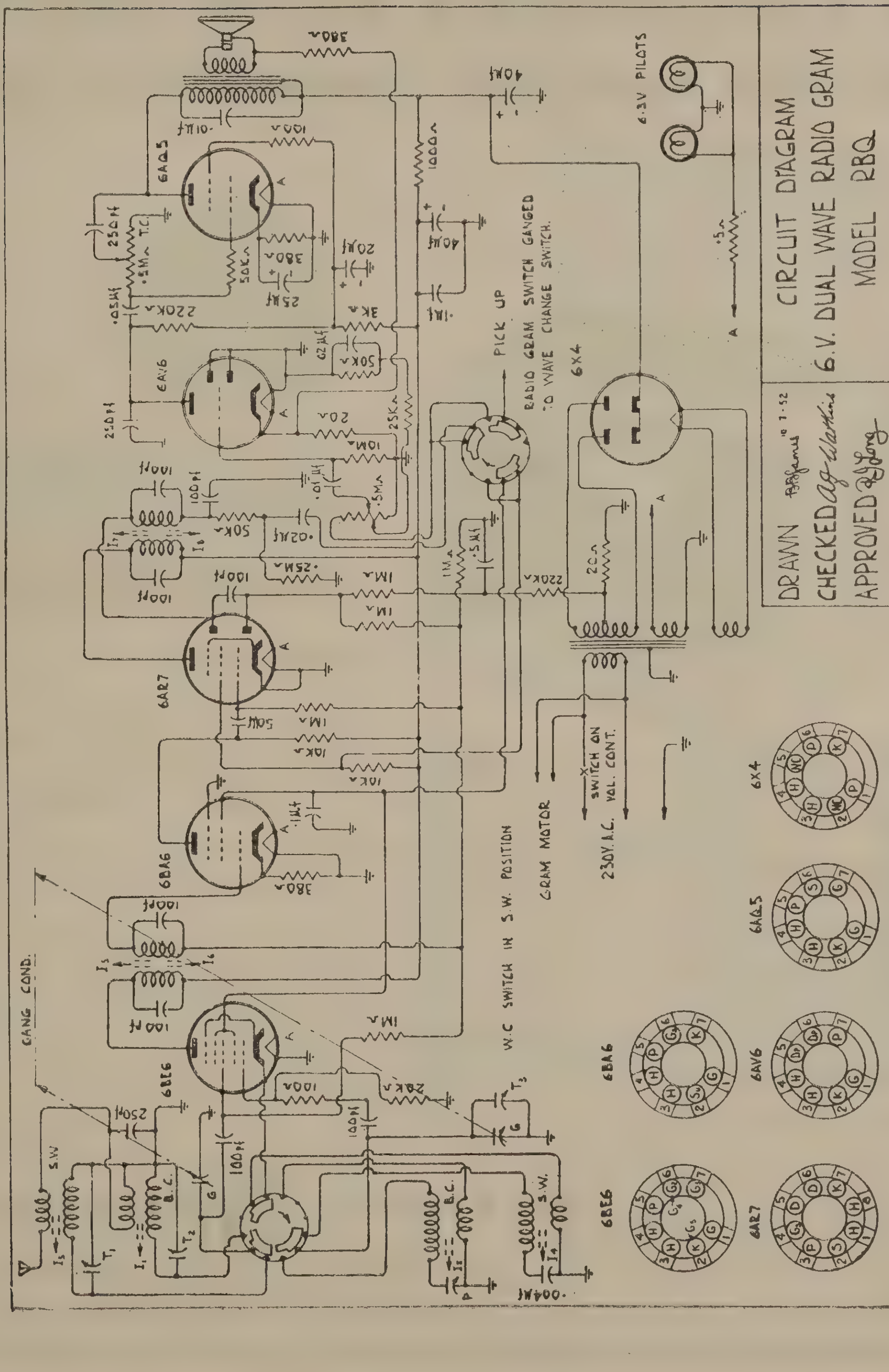
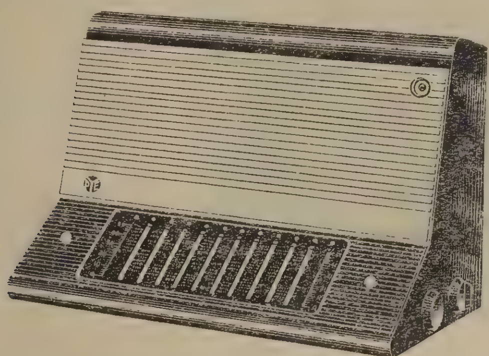


NEW PRODUCTS: LATEST RELEASES IN ELECTRICAL AND ELECTRONIC EQUIPMENT

This section of our paper is reserved for the introduction of new products and space preference is given to our regular advertisers. Advertising rates are charged according to space occupied. For further particulars contact Advertising Manager, R. and E., Box 8022, Wellington.

PYE MODEL "H"—DESIGNED FOR THE YEARS AHEAD

Acclaimed as Great Britain's most outstanding radio, this new Pye receiver is shortly to be released in New Zealand.



Up-to-the-minute in technical design, the 7-valve Model "H" (Type PZ60) worthily upholds the Pye tradition of excellence with economy: because this receiver—7 valves, magic-eye and full bandspreading—will retail at only £55 12s. 6d.

In technical excellence alone the Pye Model "H" would be well in the lead in the radio field. This plus the superb cabinet, designed for the years ahead, in sapelle mahogany with a rich cream moulded front and coloured sloping scale, makes Model "H" unbeatable.

The Model "H"—a worthy addition to the Pye range.

* * *

THE PACIFIC AND REGENT MODELS 1053
A New Luxury Radio Gramophone in a Choice of Styles

Model 1053 is a notable addition to the already outstanding range of Pacific and Regent radios and radio gramophones.

This new model console radio gramophone incorporates such luxury features as: short-wave bandspreading; separate base and treble visual tone control; full tropic-proofing; 10-valve reception of the world's programmes; 12 in. loudspeaker; famous Garrard RC75 automatic 3-speed changer player for 7 in., 10 in., or 12 in. discs.

In addition, the 1053 is available in a wide selection of cabinet designs, to make this superb radio gramophone blend elegantly and unobtrusively with any home furnishing scheme. There is a choice of either a highboy in modern styling, or lowboy in period styling.

The period models are of genuine mahogany or walnut; the modern are of blonde ash or butt walnut veneer.

The Pacific 1053 has been called the "Commonwealth" while the Regent is the "Elizabethan." Retail prices for both Pacific and Regent models range from £176 15s. to £186 15s. according to the type of cabinet.

Pacific and Regent radios are manufactured at the Waihi factory of the Akrad Radio Corporation, and distributed throughout New Zealand by G. A. Wooller & Co., Ltd., P.O. Box 2167, Auckland.

* * *

THE NEW "ULTIMATE" 6-VALVE A.C. BATTERY PORTABLE

This new Ultimate A.C./battery portable is a heavy duty portable set using two 482A batteries and one 739B battery. This set is larger than the other semi-personal portable in the Ultimate range and should find a ready market in areas where long life on battery use is required.

The new Ultimate will be equipped with a 6 in. P.M. speaker and will be available in two or more colours. The popular ivory shade, a pastel grey finish and one other colour yet to be decided.

The weight of the portable is 15¾ lb., and the life of the batteries is estimated at 200 hours.

The portable will retail at £32 13s. 6d.

It is anticipated that the demand for the new Ultimate portable will be great since there are very few of the heavy duty type of A.C./battery sets on the present New Zealand market.

TRADE WINDS

H.M.V. HONOURS EXECUTIVE

To mark the 25th anniversary of his joining the firm, fellow directors gathered in honour of Mr. R. Bull on Friday, 10th July, at a very pleasant function held in the office of Mr. A. J. Wyness, Managing Director of H.M.V. (N.Z.), Ltd. In making the presentation, Mr. Wyness paid tribute to the loyal service given by Mr. Bull over the years. H.M.V. had been most fortunate in its long-serving executives, all of whom had given of their best to the company, he said. No one, he continued, had excelled Mr. Bull, who, besides rendering such outstanding service, had been a tower of strength to him personally, especially since his assumption of the Managing-Directorship of the Company after his father's retirement.

Endorsing his son's tribute, Mr. A. Wyness, former Managing Director, wished Mr. Bull many years of health and strength, adding that he would not be surprised if a similar function were to take place 25 years hence.

Replying on behalf of himself and his wife, Mr. Bull thanked the speakers for their remarks. On first joining H.M.V., he said, he had been beset by two misgivings—one that he might not be able to make good in a job so advanced in scope to anything he had previously attempted, and the other, whether he had joined the right firm! It had been most gratifying to receive such compliments concerning his service, and were he to be given his time again, he would certainly wish to spend it with H.M.V. It is a company in the development of which he had always taken a keen interest, and during the period of his association there had been continual change and development. Briefly tracing the history of the firm, he considered that the gramophone record business, once again a major part of the firm's activties, shows every indication of continued prosperity. In his mind there was no doubt that, during his next 25 years with H.M.V., there would be further expansion of the firm's interests and its continued service to the public.

* * *

N.Z. RADIO TRADERS' FEDERATION—BROADCASTING HOURS

Unity is strength, as members of the New Zealand Radio Traders' Federation will agree, for, on the issue of cricket, the Federation played no mean part in securing extra broadcasting hours. President N. Souper has taken every opportunity to bring to the notice of the public and the Minister the trade's dissatisfaction with the reduced hours, and on this occasion, with the helpful support of the Press, the Federation has secured satisfaction for its listener customers.

N.Z. RADIO TRADERS' FEDERATION—NEW SECRETARY

At its recent Annual Conference held in Christchurch, Mr. C. I. W. Archibald was appointed Secretary of the New Zealand Radio Traders' Federation. His address is P.O. Box 322, Wellington.

* * *

New manager of the Kaiwharawhara factory of National Electrical and Engineering Co., Ltd., is Mr. W. Fettes. He succeeds his former chief, Mr. J. K. Scobie, who recently resigned to become General Manager of William Cable & Co., Ltd., Wellington.

£1,000,000 ELECTRICAL AND RADIO EXPOSITION

In October, 1954, Melbourne, Victoria, will be the venue of a mammoth exposition covering the latest in electrical equipment and appliances, radio, radar, television and telecommunications, and embracing exhibits from all over the world.

* * *

3-D TV IN AMERICA

A sample of what we may expect to see on television some day was demonstrated recently in Los Angeles, when an experimental three-dimensional television programme by the American Broadcasting Company was received on special sets which projected polarized images on a 3 x 4 ft. screen. To get the illusion of depth, viewers wore special glases of the type used for three-dimensional films.

This was a demonstration to show the progress made in 3-D television research, but the company emphasized that much more development was required before it would be practical for use in the home. The images were in black and white, but it was stated that the method would work equally well in colour television.

BACK NUMBERS OF "R. & E."

Back numbers are available from:—

Te Aro Book Depot, Courtenay Pl., Wellington.
S.O.S. Radio, Ltd., 283 Queen Street, Auckland.
S.O.S. Radio, Ltd., 1 Ward Street, Hamilton.
Tricity House, 209 Manchester St., Christchurch.
Ken's Newsagency, 133-135 Stuart St., Dunedin.

CLASSIFIED ADVERTISEMENTS

FOR SALE—High quality transportable tape recorder with playback amplifier, with three Bradmatic heads; frequency 40 to 12,000 c.p.s. at 7½ in. sec. Demostration gladly given. £180. Reply "Quality," c/o *Radio and Electronics.*

* * *

FOR SALE—Best offer between £25 and £40 secures R.C.A. AR77E communications receiver in excellent condition. 10 tubes, 6 band switching, "S" meter, crystal filter, etc., 550 kc/sec. to 30 mc/sec., temperature compensated, amateur bands directly calibrated in frequency. Reconstructed relay rack mounted. Money refunded if not satisfied at end of two weeks. Must sell. D. W. Martin, c/o P. Martin, c/o Post Office, Whakatu, Hastings.

WANTED to Purchase.—Communications Receiver, 550 kc/sec. to 25 mc/sec., with no missing bands. Complete with B.F.O. and A.V.C., R.F., and Audio Gain Control. Sharp selectivity on one position but crystal filter not necessary. Telephone Prof. Peddie, V.U.C. Phone 46-046, Wellington.

British Radio's Finest Year—TV and Electronic Triumphs Displayed to The World

(FROM A CORRESPONDENT)

The British radio, television, and electric industry in coronation year is having a series of triumphs embracing the Coronation itself and culminating in what will undoubtedly be the world's largest and most comprehensive radio exhibition and demonstration.

The communication and electronic equipment side of the industry started off in May with an exhibition which for security reasons could not be fully reported at the time. It was, however, the largest and most comprehensive exhibition of electronic equipment ever arranged in any part of the world. Organized primarily for inspection by representatives of countries in the North Atlantic Treaty Organization, it included much equipment for civil use among which might be mentioned the following:

Television flying spot scanner microscope—it scans a slide beneath an optical microscope and the image is seen on a $3\frac{1}{2}$ in screen.

Airmen's dinghy transmitter, measuring 4 in x 2 in., with a range of 60 miles; powered by a Kalium cell which will last for 36 hours at normal temperature and for 24 hours at 0°C.

New airfield radar approach equipment, including mobile units for secondary airfields.

Portable industrial television unit, with camera which can be remotely controlled from a distance of up to 600 feet.

Tape recorders for special signals, one with an unusually wide frequency band (zero up to 25,000 cycles) and another for very low frequencies (up to 150 cycles).

Distance-measuring equipment (DME), a development of the "Rebecca" homing device for aircraft as used in the war, but with a range now—with suitable ground equipment—of up to 200 miles, enabling a high-speed aircraft like the Comet to start making its descent in good time and accurately.

"Sarah" rescue system, sub-miniaturization being used in a small beacon transmitter attached to the life-vest. This emits coded pulses which are displayed on a cathode ray tube aboard the searching craft.

Portable microwave equipment similar to that used for taking TV pictures of the coronation from England to the Continent.

The coronation television link to the Continent worked splendidly, bringing the B.B.C. high praise for its pictures from France, Belgium, Holland, and Germany, and for its "tele-recordings"—films made from the live TV broadcast—from Italy, Scandinavia, Canada, and the U.S.A. A spokesman of one of the leading American television networks cabled, "This is television's finest hour."

A notable point was that what the Continental countries saw and praised so much was technically just the normal British television picture, produced by standard British equipment, no extra or special equipment being used for the Coronation. But behind these unprecedented transmissions lay, of course, the fact that the British radio industry and the B.B.C. have longer experience of TV than their opposite numbers in any part of the world.

Television continued to follow Her Majesty on her various drives through London, and visits to Scotland and Wales, and a notable event was the televising of the naval review at Spithead when television cameras and a transmitter were installed in the aircraft carrier H.M.S. *Eagle* and the salvage ship *Reclaim,* the pictures being relayed throughout the country. These were the first B.B.C. television transmissions from a ship at sea.

British manufacturers are now making TV equipment to any standard required—the Continental 625-line system or the American 525-line system—and exports of receivers have begun in earnest. Transmitters and complete television studio equipment have been British exports for some time.

A big overseas attendance is expected at the 20th National Radio Show at Earls Court, London, from September 1 to 12, the first day being specially reserved for overseas visitors and other important guests. In an illustrated booklet entitled "British Radio Leads the World," announcing the Show, the President of the Radio Industry Council, Lord Burghley, writes:

"In Britain, our visitors will experience what is, we believe, universally accepted to be technically one of the most efficient broadcasting systems in the world: that

of the British Broadcasting Corporation. The B.B.C. was first in the world to have a regular television service, and first to establish international exchange of television programmes: from the Continent to England last year, from England to the Continent with the Coronation programmes, this year.

"The British television service today is available to 80 per cent. of the population, a higher proportion than in any other country. This is made possible by the use of the five most powerful TV transmitters in the world, plus two which, although of lower power, are equal to the most powerful in any other country.

"In this, the newest field of technical skill, the traditional integrity of the British engineer is fully upheld. The industry, by its equipment, and the B.B.C. by its skill in specifying and using it, can jointly boast of producing consistently a television picture that is second to none in the world.

"Broadcasting, sound and television, are the main theme of the Radio Show at Earls Court, for there the exhibitors include all our members manufacturing domestic receivers, including special models for export covering all the necessary wavebands, with special tuning scales for the particular market, and 'tropicalized' down to the last component for hot climates.

"There also, in operation all day, equipped with the latest British equipment, based on our 'know-how,' is the full-size B.B.C. television studio, in which programmes may be seen in the making and on the air."

Missing and Stolen Radios

Police Station, Rotorua:

Philips mantel model 126, serial No. 51028, brown cabinet.

Criminal Investigation Branch, Wellington:

State, 5-valve, "All Round Sound" radio, serial No. 6085. Walnut plastic cabinet.

Philco, 5 or 6 valve model, serial Nos. W1 6903 and 39965.

Ford 2-valve radio tuning unit, serial No. either 6148 or 6208. Brown steel cabinet 9 in. x 5 in. x 2 in., "1" dial with white background and dark letters and numerals: white tuning and control knobs.

Home-made radio in two sections: 5-valve tuning unit with condenser in grey crackle cabinet 10 in. x 8 in. x 5 in., with air louvres at sides. Similar case for speaker unit containing vibrator, speaker, and 1 valve. On cabinet with disc dial, one tuning and one volume knob. Speaker grille in shape of shamrock, covered with flowered cretonne.

Criminal Investigation Branch, Dunedin:

Ultimate 6-valve A.C./D.C. personal portable, complete with batteries; serial No. 150481; brown bakelite cabinet.

Police Station, Patea:

Columbus 12-volt auto radio; serial No. 86440; brown wrinkle cabinet 10 in. x 6 in. with two holes on top each side, glass face, white figures, black dial.

Criminal Investigation Branch, Greymouth:

Golden Knight R.A.W. 5-valve battery/electric portable; serial No. 145194; white plastic case 14 in x 8 in. x 6 in. with carrying handle attached.

Police Station, Paeroa:

H.M.V. model 496 A-R, 6-valve, auto radio; serial No. 145900; black bakelite cabinet with small piece broken off under dial.

Aerial, three-piece chromium-plated aerial; centre mounted on cowling; five feet long when fully extended.

Criminal Investigation Branch, Auckland:

Philips 5-valve mantel model 461; serial No. 61606; dark brown bakelite cabinet. Radio needs repairs.

Criminal Investigation Branch, Napier:

Pacemaker battery/electric portable; serial No. 17740A; brown bakelite handbag shaped case with white plastic carrying handle on top; switch at back for battery or electric power; opens front with white dial on inside of lid; two white control knobs.

Proceedings of the New Zealand Electronics Institute Incorporated.

COUNCIL

With the aid of a telephone link, the final meeting of the old Council was held simultaneously in Wellington, Christchurch, and Dunedin on May 27th. Eight applications received from the admissions committee were admitted to membership of the Institute, Mr. B. T. Withers, the President, congratulating the Dunedin Branch on its splendid efforts to obtain new members. The chief business of this Council meeting concerned the transfer of Dominion Headquarters to Dunedin.

* * *

ANNUAL GENERAL MEETING OF THE INSTITUTE

The fifth Annual General Meeting of the Institute was held in Dunedin, on June 25th. In the absence of the President, Mr. B. T. Withers, Mr. H. F. Symmons presided over a meeting of 29 members, apologies being received and sustained from Messrs. Withers and Hurrell.

In his Annual Report read at the meeting, the President stated: "At the commencement of the year it was realized that the Institute was not developing as members would wish and Council took an incisive and realistic view of the difficulties being met and likely to be met in the years to come. A very large block of unfinancial members was in existence, and it was considered that every effort should be made to curtail expenses and effect economies, whilst at the same time giving mature consideration to the lines of development of the Institute and to consider realistically the chances and possibilities of fulfilling those objects.

Remits were framed by Branches desiring the continuance of the Institute, and the possible transfer of headquarters to a centre other than Wellington was suggested. Council considered the possibility of transfer to either Christchurch or Dunedin with an honorary secretary who was to be paid an honorarium of £50 per annum. However, Dunedin and Christchurch could not find an honorary secretary on the terms suggested. Tentative discussions with Mr. Arnold Thornicroft, B.Com., A.P.A.N.Z., A.C.I.S., A.C.A.I., were undertaken by Dunedin Councillors concerning his possible acceptance of the post of Dominion Secretary. Council then set the machinery for the transfer of headquarters to Dunedin in motion, and this is in process of being effected.

It was considered that the Institute's block subscription to *Radio and Electronics* was overburdening some members financially and after an expression of opinion of all members had been taken, the matter was put to the vote of corporate members. The vote carried the discontinuation on a compulsory basis of receipt of the publication.

The matter of official recognition of Institute qualifications by Government departments and industry has been under investigation by a committee of Council without positive results.

The desirability of continuing or reinstating Institute examinations is currently under investigation.

Active branches exist in Wellington, Christchurch, and Dunedin and, although a number of financial members reside in Auckland no branch activities have taken place there during the current year.

With the coming year, it is hoped that worthwhile economies will be effected and that some mature consideration of means and methods of implementing the aims and objectives of the Institute will be evolved and acted upon. Suggestions concerning these means and methods will, it is hoped, come from the rank and file of membership and through active branches."

S/Lr. Partelow, of Christchurch, stressed the need for economies in Institute affairs and the maintenance of membership at the highest possible number. It was resolved "That the Council should adopt a suitable scheme to interest past and present members in the affairs of the Institute, and to ascertain from them the probable number who would remain members or reinstate their membership for the current year."

Formal business concluded at 8.15 p.m., but, owing to the unconstitutional arrangements for the intended Special General Meeting, the matter of the N.Z.E.I. subscription could be discussed only informally. As a result, the following substantive motion was passed *as a recommendation only to Council*:

(a) That the subscription rates to the N.Z.E.I. Inc., for the year 1953-54 be the same as for 1952-53, except that for members not wishing to subscribe to *Radio and Electronics* a credit shall be allowed of such an amount as shall be determined by the Council.

(b) That this recommendation be forwarded to the Branches in order that votes may be recorded in accordance with rule 16 of the constitution.

JUNE MEETING OF DUNEDIN BRANCH

Immediately following the conclusion of the Dominion A.G.M. of the Institute, the monthly meeting of the Dunedin Branch took place, with Mr. W. L. Shiel presiding. After consideration of the Television Subcommittee's report, it was decided that the Branch should associate itself with the King Edward Technical College in the construction of a suitable signal source and its operation, preferably a TV transmitter, so that signals would be available for reception by the receivers already being constructed at the college.

Speaker for the evening was Mr. W. G. Collett, B.A., his subject, entitled "The Principles of Television," covering the bandwidths involved and the means of obtaining these.

DUNEDIN BRANCH

Presided over by Mr. W. L. Shiel, the Dunedin Branch held its Annual General Meeting on May 21st.

In his report upon the Branch activities during the past year, the Chairman stated that there had been 12 monthly meetings with an average attendance of 19,

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showing a slight increase over the previous year. The most outstanding success was the lecture by Messrs. Symmons and Anderson on "High Fidelity, Is it Worth It," which attracted a large audience and received very satisfactory Press publicity. Future prospects of the Dunedin Branch were outlined and confidence expressed that, in view of the grading alterations now in force, the coming year will be one of progress. A number of new members have been accepted, and many inquiries re membership have been received since these changes, which were achieved by the persistent efforts of the Dunedin Branch.

Unfortunately, the financial statement was incomplete owing to the non-receipt from the Dominion Secretary of details of subscriptions received direct by Headquarters and the cheque for capitation fees. On the motion of Mr. Harris the presentation of the balance-sheet was deferred until the next branch meeting.

The election of officers resulted as follows:—

Chairman: Mr. W. L. Shiel.
Vice-Chairman: Mr. H. Symmons.
Treasurer: Mr. W. McInnes.
Secretary: Mr. E. S. Anderson.
Committee: Messrs. W. G. Collett, P. Holden, and I. Hall.
Social Committee: Messrs. Clarke, Stone, Holden, Walker, and Adam.

The report from the Branch committee on the feasibility of establishing a television project in Dunedin was received with general approval, and a sub-committee appointed to report to the Branch at the earliest opportunity, details of the type of TV project, and the form it should take.

The meeting concluded with the screening of three films entitled "Cable Laying in Cook Strait", "The Manufacture of Steel and Steel Tubes," "The Laying of 'Pluto'" (the pertol pipeline between Britain and France during the war).

PUBLICATIONS RECEIVED SINCE 15/6/1953

A.W.V. Radiotron Valve Data Book—Amalgamated Wireless Valve Co., Pty., Ltd., Sydney, N.S.W., Australia.

Equivalent Radio Tubes Vade-Mecum—P. H. Brans Ltd., Antwerp, Belgium.

Rola Loudspeaker Data, June, 1953—Rola Company (Aust.), Pty. Ltd., Melbourne, Australia.

Leaflet No. 1-SMO-153 from the F.J.E. Machine Centre, F. J. Edwards Ltd., London (Levin and Co., Ltd., Wellington).

A.P.A.E. Journal, Vol. 4, No. 4, April, 1953.

B.I.C.C. Directors' Report and Accounts with Chairman's Statement for Year ended 31st December, 1952—British Insulated Callenders and Cables Ltd., London.

Turnbull and Jones Ltd., Price List, March, 1953—Turnbull and Jones, Wellington.

Jenolite News, Vol. 5, Nos. 2 and 6—Jenolite News, London.

Radiotronics, Vol. 18, No. 6, June, 1953—Amalgamated Wireless Valve Co. Pty. London., Sydney.

Philips Bulletin, April/May, 1953—Philips Electrical Industries of N.Z. Ltd.

"Thinking Ahead," No. 3—The Reciprocal Trade Federation of the United Kingdom.

A.P.A.E. Journal, Vol. 4, No. 5, May, 1953—Association of Public Address Engineers, Middlx., England.

Wireless and Electrical Trader, Vol. 90, Nos. 1184 and 1185.

Wireless and Electrical Trader Year Book, 1953—Trader Publishing Co. Ltd., London.

Radiotron Receiving Manual—Amalgamated Wireless Valve Co. Pty., London, Australia.

British Radio Leads the World, Earls Court September 1-12, 1953. Radio Industry Council, London.

Pye at the Coronation, Pye News Letter, Special Edition—Pye (N.Z.), Ltd.

"Enterprise" No. 24, June, 1953—Cory-Wright and Salmon, Ltd., Wellington.

N.Z. Electrical Journal, Vol. 26, No. 6.

A.T.E. Journal, Vol. 9, No. 2, April, 1953—Automatic Telephone and Electrical Co., Ltd., England.

"Technique" Vol. 7, Nos. 1 and 2, January and April, 1953, Muirhead and Co., Ltd., England—Richardson McCabe and Co., Ltd., Wellington.

"Aerial," April, 1953, Marconi's Wireless Telegraph Co., Ltd., England—Amalgamated Wireless (Australasia) Ltd., Wellington.

Intermodulation Distortion

(Continued from Page 11.)

in accordance with modern practice, we call maximum output that at which the IM distortion is 4 per cent.—a rating that entitles the amplifier to the appellation "high-fidelity"—the output would be only 48 volts. Thus, since power in a given load resistance is proportional to the square of the output voltage, as a high-quality amplifier this one would be rated at only 60 per cent. of the rating based on 3 per cent. harmonic distortion. Incidentally, this example shows how the intermodulation distortion can be considerably less than the harmonic distortion over a considerable range. Indeed, this amplifier would probably give excellent performance up to 45 volts output, with very little audible distortion at all, since pure harmonic distortion is difficult to hear, and up to this output the intermodulation distortion is very low.

At a later date, we hope to give details in this series of an oscillator and high-pass filter suitable for the Le Bel method of IM measurement.

"R. & E." TECHNICAL PHOTOGRAPHS

Copies of original designs produced in our laboratory and featured in these pages are available. Prices are: Size 6 in. x 4 in, 3s. 6d.; 8 x 6, 4s. 6d.; 10 x 8, 5s. 6d. Please remit cash with order to Radio and Electronics

Philips Experimenter

(Continued from Page 26.)

back resistance, and it sometimes becomes important to decide which of these best suits the application in view. In a case like this, the decision depends upon the signal voltage at which the diode has to work, and upon its back resistance at that voltage. If the signal voltage is not likely to vary, then the best diode will be the one with the highest back resistance at that voltage.

It is hoped that these notes will have given Experimenter readers some idea of the differences between crystal and thermionic diodes. In the next issue of the Experimenter we propose to give the detailed characteristics and ratings of the complete Philips range of germanium diodes, together with the types numbers of their American equivalents, and also to give some representative circuits illustrating their applications.

Abstract Service

(Continued from Page 23.)

MATERIALS, VALVES, TRANSISTORS, AND SUBSIDIARY TECHNIQUES—Continued

ject. Notes are give on stabilizers employing grid-controlled rectifiers, voltage stabilization of Van de Graaff generators, and also for television transmitters and other miscellaneous circuits.

—*Ibid*, p. 202.

The application of the magnetron in the communication and television fields has been limited chiefly by the lack of an accurate control element. The power output, pushing and pulling factors and oscillator starting current can now be controlled by a grid controlled device. It has been found possible to lock the magnetron's frequency to an external low-level crystal controlled signal and the grid also facilitates modulation. This new type of magnetron greatly enlarges the uses of the device in radar and television fields.

—*Electronics* (U.S.A.), May, 1953, p. 149.

A further article on transistor theory: herein the author presents a concept of the electron that fits generally accepted explanations of phenomena within semi-conductor materials that are responsible for transistor action. The electron behaves both like a corpuscular particle and an electromagnetic wave, and some of its attributes are made clearer by the study of transistor action.

—*Ibid*, p. 165.

MATHEMATICS

The measurement of phase shift by the cathode ray oscilloscope. The article outlines briefly the procedure to be adopted. Two measurements of deflection against a cross hatch grid-overlay show possible phase angles when entered in the nomograph accompanying the article. Rotation of the beam resolves the ambiguity.

—*Ibid*, p. 192.

RECEIVERS

The design, construction, and performance of an "independent-sideband" receiver suitable for use on long-distance point to point radio links is described. The independent sideband signal comprises a reduced level pilot carrier and two 6 kc/sec. sidebands. The receiver described closely approaches the limits of performance theoretically obtainable in respect of such an instrument.

—*The Post Office Electrical Engineers' Journal* (Eng.), April, 1953, Part I, p. 19.

In the tuning apparatus described, a tuning mechanism scans the broadcast band at 200 kc/sec. and stops within a kilocycle of the next usable signal in sequence. The apparatus is especially designed for automobile receivers, and is so arranged that if the gain of the receiver is reduced the tuner will stop only on strong local stations. The action depends upon a second-detector trigger circuit which actuates a solenoid that cocks a spring motor.

—*Electronics* (U.S.A.), May, 1953, p. 154.

The author reports on a two-valve receiver he has successfully used for some time which has great simplicity of design and a minimum number of components. The essential feature lies in the employment, as detector, of a pentode (EF50) operated with a low screen potential and an unusually high value of anode load resistor, giving a very high-gain stage. The anode potential being reduced enables a direct coupling to the next stage. This is therefore a very interesting little model which commends itself immediately to the experimenter.

—*Wireless World* (Eng.), May, 1953, p. 233.

5-Valve Receiver

(Continued from Page 7.)

ler is in the grid circuit, while the tuned circuit is in the plate of the oscillator section of the ECH21. This arrangement has certain advantages over the conventional grid-tuned oscillator circuit, but we have not the space here to go into an academic dissertation on their respective merits. Here, the choice was more or less dictated by the maker of the coils, who has arranged the oscillator coil to be more suitable for a plate tuned circuit, if used with this type of valve.

CONSTRUCTION AND WIRING

The diagrams given in this part of the article will enable anyone to make the necessary metal-work, but since the construction is rather unusual in the R.F. section of the set, we are having a special series of photographs taken which will illustrate the construction rather more fully than usual. These photographs will appear in the second and final part of this article, in next month's issue of *Radio and Electronics.*